



# Nucleus accumbens core lesions decrease reward magnitude sensitivity in steady state impulsive choice



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## 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 (larger-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 impaired choice behavior such as drug use, gambling, and poor financial decisions.
- Conversely, **self-control** is a predictor of adaptive choice behavior, such as improved school performance, better interpersonal relationships, and better financial decisions.
- Impulsive choice behavior is also linked with ADHD<sup>1,2,3,4</sup> and this may be due to an over-responsive **Nucleus Accumbens core (NAc)**<sup>5</sup>.
- NAc is believed to play a central role in determining the value of rewards that guides choice behavior.
- Our previous research<sup>6</sup> with NAc lesions indicated deficits in adjusting to increases in reward magnitude, so that when reward magnitude increased, choice behavior did not change significantly.
- Also, recent work from our lab<sup>7</sup> showed that dynamic tasks may result in more random and more impulsive behavior.
- The previous NAc lesion studies<sup>6,7</sup> used **dynamic procedures** and thus may be susceptible to non-specific deficits of the lesions when dealing with dynamic environments.

**Purpose:** Here, we tested NAc lesions in a **systematic steady state procedure** that maximizes opportunities for learning the reward options. Also, we tested **reward sensitivity** in the absence of differences in delay to verify the effects. We determined whether the NAc is necessary for the computation of reward value in an impulsive choice task, when the magnitude of reward for one of the alternatives was increased over phases.

**Hypothesis:** Rats with NAc lesions should show deficits in adjusting to increases in LL magnitude in comparison to sham control rats.

## 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).



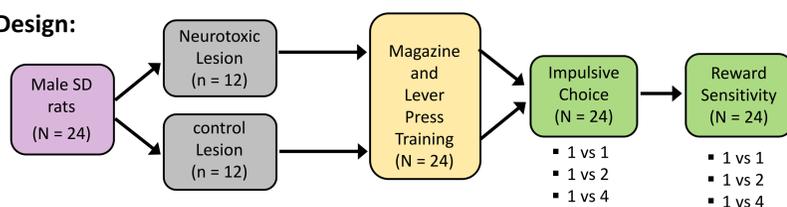
## Procedure

**Surgery:** Rats received **neurotoxic lesions of the NAc** or **control lesions**.

### Surgical procedure:

- Rats anesthetized with isoflurane
- Rats placed on a stereotaxic frame
- 1-2 cm incision at top of the head
- Skull exposed and bregma located
- Holes made with precision drill (at each side of skull to dura)
- 30 gauge infusion needle injected bilaterally:

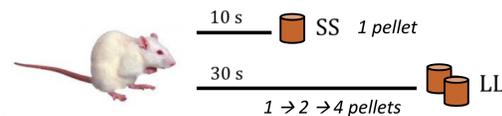
### Design:



## Methods (Cont.)

### a) Impulsive choice task

- Modification of the Green and Estle (2003)<sup>8</sup> procedure:
  - Rats were exposed to the same magnitude for several sessions
  - The LL and SS delays remained the same throughout testing
  - Session = 82 trials → *Randomly intermixed* = 54 Free Choice + 14 SS Forced Choice + 14 LL Forced Choice
  - LL reward incremented systematically across phases (*1 phase = 15-20 sessions*)
  - Trained on each magnitude until stable choice behavior was reached



### Free choice trials:

- Both levers (left + right) = SS or LL → *Counterbalanced across rats*
- The choice initiated a delay until food was available to be delivered

### Forced choice trials:

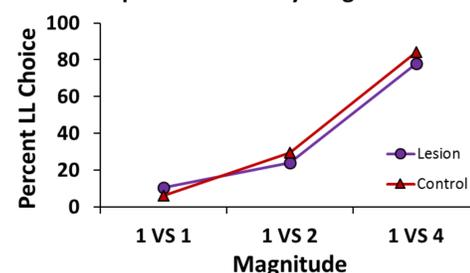
- Only one lever presented = SS or LL → *Counterbalanced across rats*
- Lever press initiated a delay until food was available to be delivered

### b) Reward sensitivity task

- Both levers (SS + LL) presented → each with a **VI 30 s schedule of reinforcement**.
  - Variable-interval (VI) = mean interval is 30 sec, but delays varied (1-59 sec)
  - Reward magnitude manipulation: SS = 1 pellet ; LL = 1 → 2 → 4 pellets

## Results

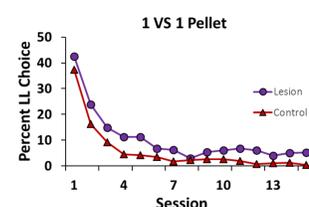
### Impulsive Choice by Magnitude



### Figure 1:

- The rats began by making more SS choices then progressively switched to LL choices as the magnitude increased.
- Differences in percent LL choice are evident between the groups. The control rats made more LL choices overall.

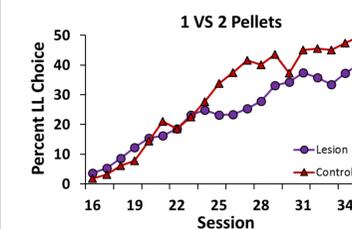
Logistic mixed effects multilevel modeling revealed significant main effects of Group (lesion/control), Magnitude, and Session, as a Group\*Magnitude\*Session interaction, and a significant random effect of Magnitude.



### Figure 2:

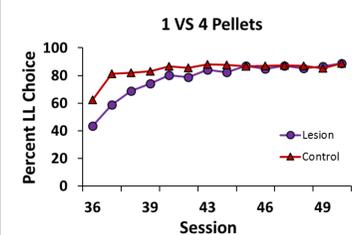
- When both the SS and LL option were 1 pellet, the control rats quickly chose the SS while the lesion rats took longer, but eventually made more SS choices.
- The lesion rats never reached exclusive SS choice and instead continued to wait for one pellet on a subset of trials.

## Results (Cont.)



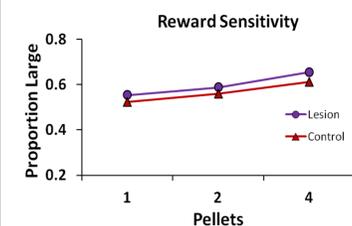
### Figure 3:

- The control rats made more LL choices while the lesion rats made significantly fewer LL choices.
- In contrast to the control rats, the lesion rats persisted in preferring the SS even though the LL magnitude was now 2 pellets.



### Figure 4:

- The control rats increased their LL choices within 1-2 sessions.
- In contrast, the lesion rats continued making SS choices. They did; however, make more LL choices in comparison to the other conditions.



### Figure 5:

- Control and lesion rats responded similarly in the reward sensitivity task.
- Both control and lesion rats increased large lever choices with increasing magnitude.



## Conclusions

- The results for each magnitude show that the control group responded to changes in LL magnitude more quickly than the lesion group. They were better at maximizing rewards by quickly migrating towards the better option, whereas the lesion rats were slower to do so.
- The NAc lesion rats may have deficits in behavioral flexibility, that would be worth further study.
- The reward sensitivity results indicated that lesion and control rats were similar in differentiating reward magnitudes, indicating that the choice deficits were not due to poor reward discrimination.
- This shows the significance of the NAc in the value of rewards and decision making but reveals that reward sensitivity alone may not be affected in NAc lesions.
- It also indicates that the lesion caused deficits even with a systematic, steady state procedure which should result in maximum learning opportunities.

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