



Nucleus accumbens core lesions have little effect on temporal sensitivity in 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 many problem behaviors such as:
 - drug use •smoking •overeating •poor financial
 - gambling •drinking •stealing decisions
- Impulsive choice behavior is also linked with ADHD^{1,2,3,4} and this may be due to an over-responsive **Nucleus Accumbens core (NAc)**⁵.
- NAc is believed to play a central role in determining the value of rewards that guides choice behavior.
- Our previous research⁶ 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.

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)

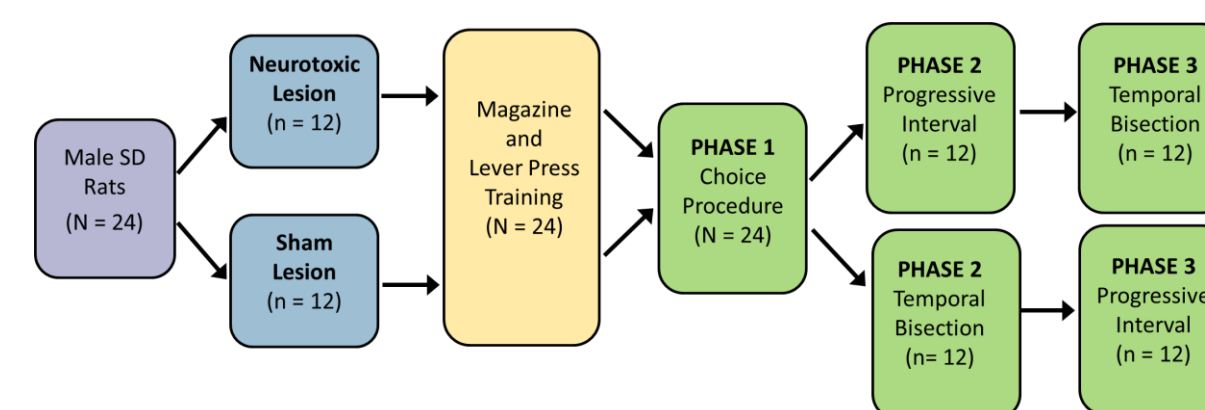
Procedure

- Surgery.** Rats received neurotoxic lesions of the NAc or 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:
Neurotoxic lesion of NAc (12 rats)
- 0.5 µl of 0.1 M PBS into brain tissue:
Sham lesion (12 rats)

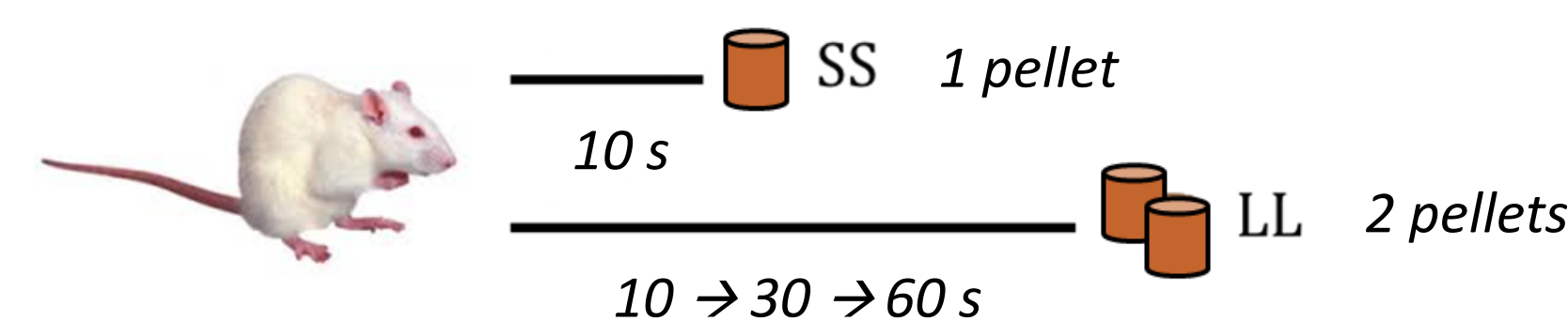
- Training and Testing.**



Choice Procedure:

Modification of the Green and Estle (2003)⁸ procedure

- Session = 82 trials → *each with a 60-s fixed ITI*
54 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) ; **Incorr = (5 s ITI)**
- **Testing.** 10 sessions = 2 x each cue duration → 4, 5.26, 6.92, 9.12, 12 s

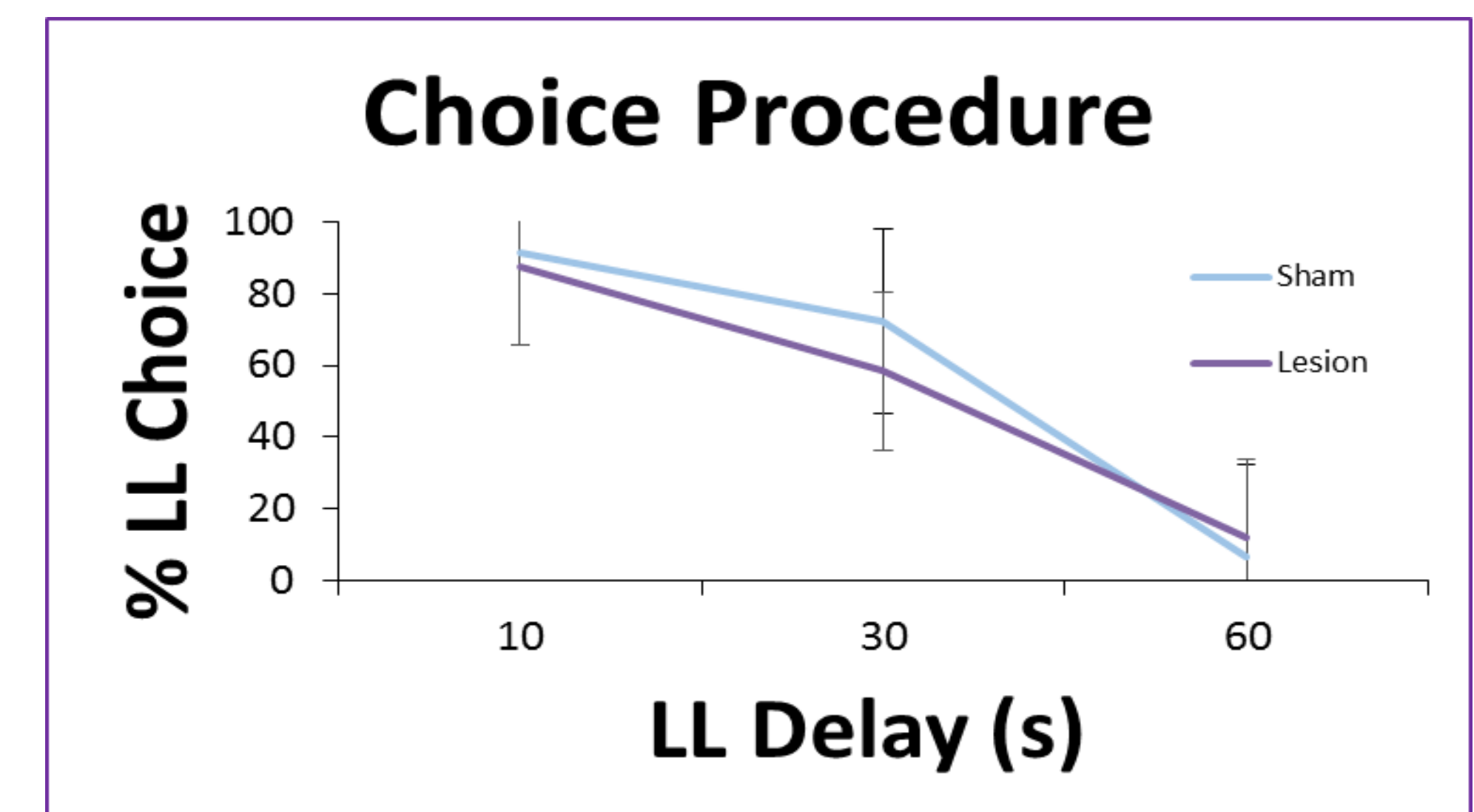
Progressive Interval (PI) Schedule:

Adapted from Marshall, Smith and Kirkpatrick (2014)⁹ procedure

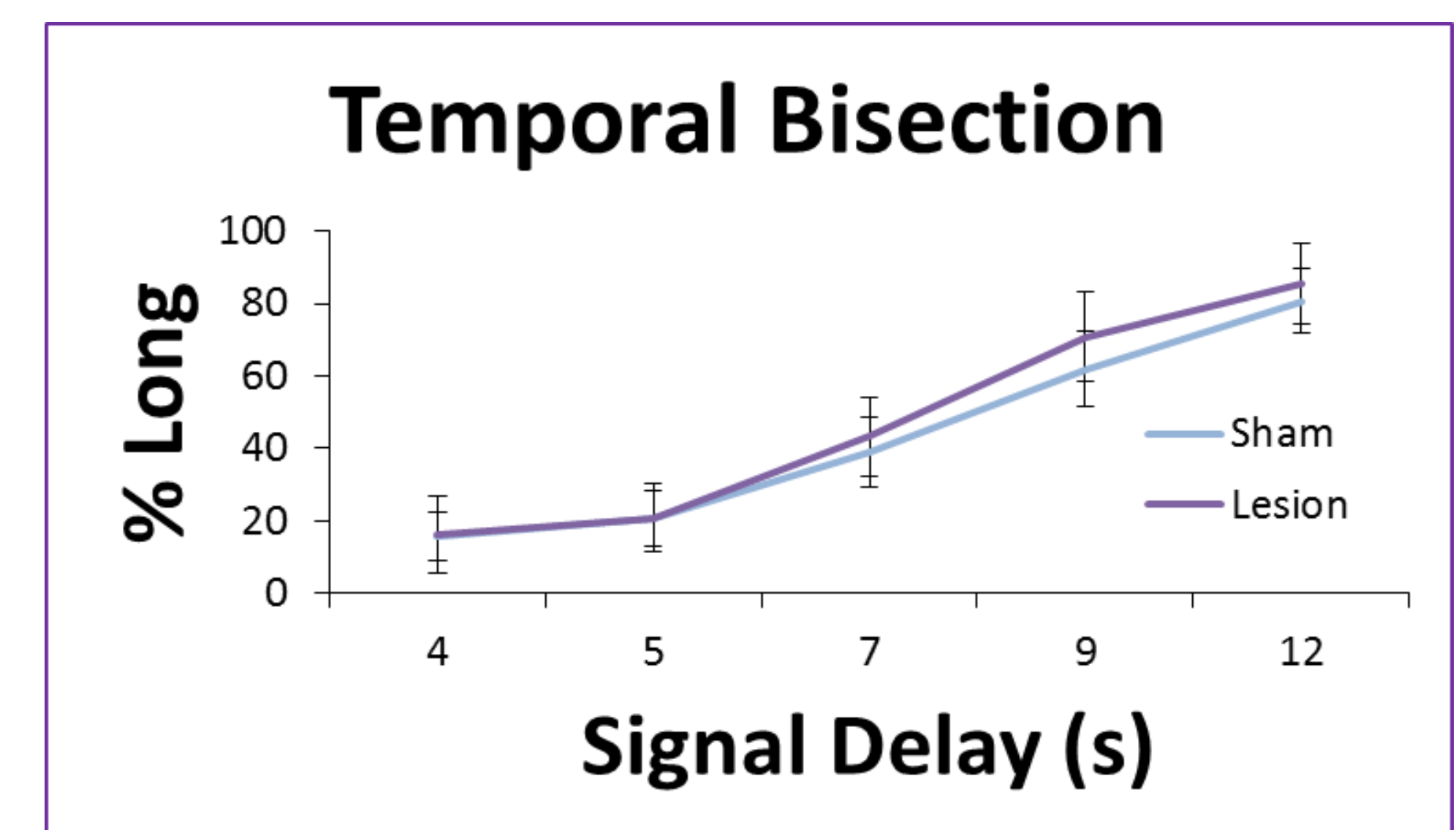
- Delay incremented arithmetically by the PI duration for each subsequent trial
Only one lever = 1 pellet → 5, 10, 30 s
- Number of reinforcers earned evaluated at each delay

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

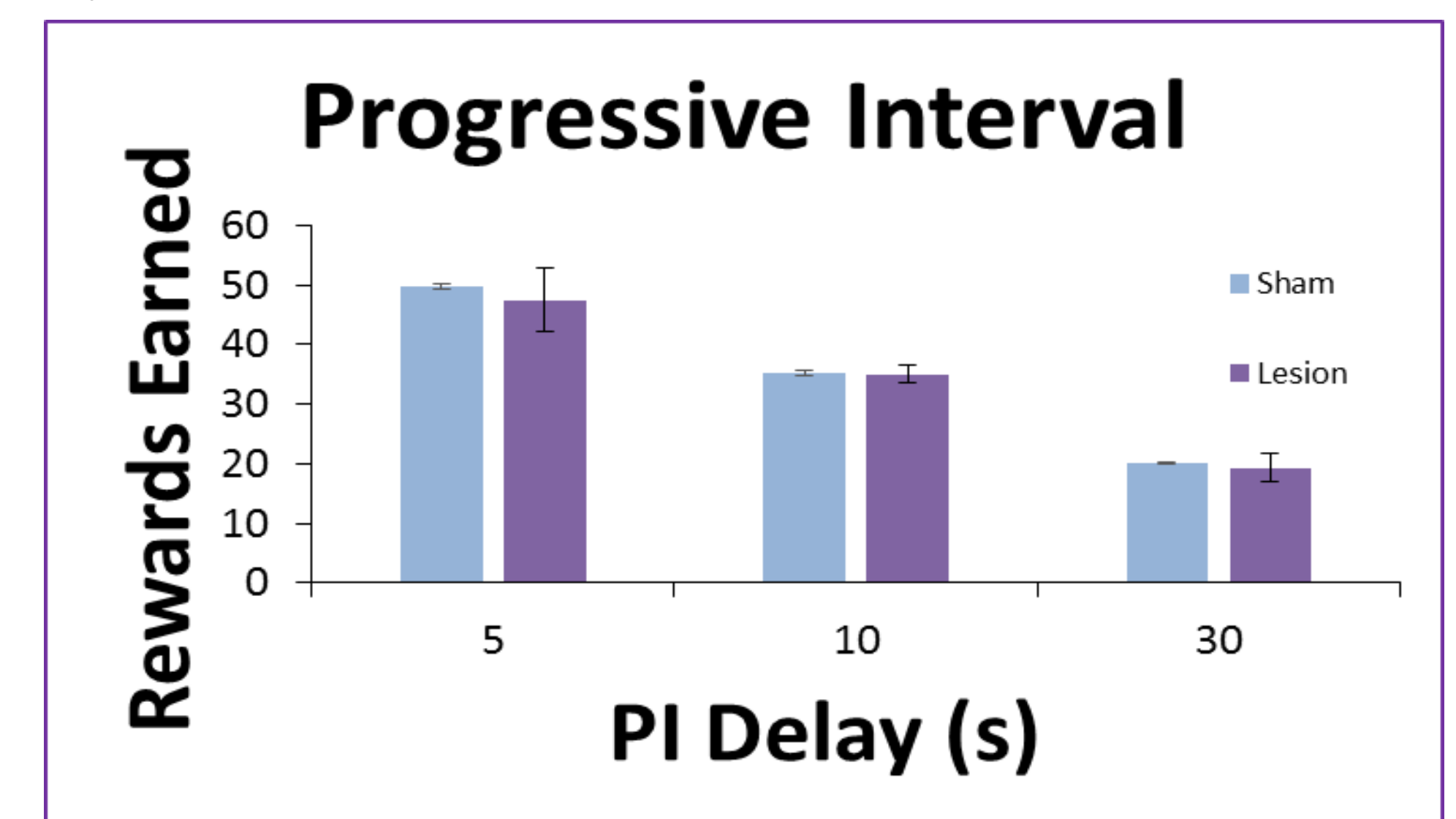
Results



- 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.

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.

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