Teaching Rats to Drive: A Novel Method for Spatial Navigation Research in the Rat

Olivia Harding, Xiaodi (Sara) Hu, Peizhi (Paige) Li, Ally Maner, Ethan Rozario with Dr. L. Beth Crawford
Psychology Department, University of Richmond, VA 23173

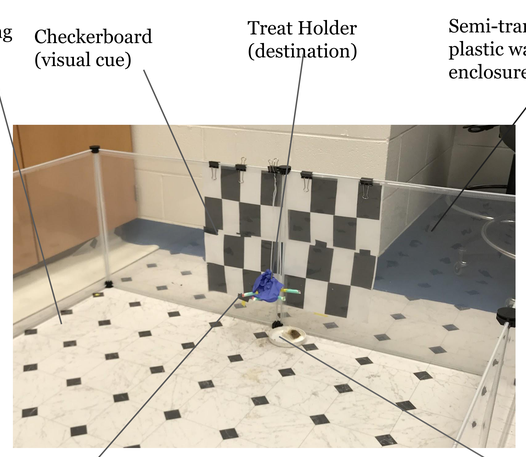
Background

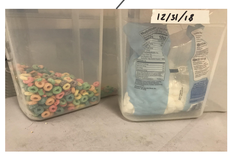
Spatial Navigation
Spatial learning research in rodents is a popular theme. However, previous research tends to consider spatial navigation in the natural context of running on foot as the primary means of locomotion. Past research either let rats have the freedom to navigate and run at the same time or restricted their running ability and navigation together.

A New Approach
The current study aims to separate spatial navigation from running on foot and explores the necessity of running in spatial navigation by introducing rats to a car they can drive. Driving is an unnatural behavior for rodents, so operant conditioning is used in the teaching process.

Sequencing
Using a specialized protocol, six female rats were taught to sequence the behaviors of turning right and moving forward at specified, increasing distances to reach the intended destination with reinforcers.

Environment and Equipment





Froot Loops reinforcers

Marshmallow adhesive to attach Froot Loops to the treat tree

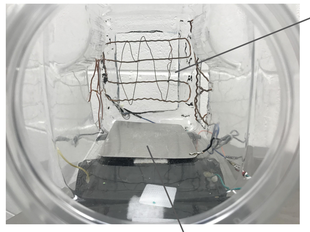
Treat Tree/holder (currently used) support for reinforcers and the destination during driving

Cinnamon Herbal Tea olfactory cue

Rat Car Design

Previous Design
Through shaping with reinforcement, we at first taught rats to push a joystick forward to let the car go forward (Summer 2018). The rats were able to drive a distance of five feet at maximum. However, turning the car to the left or right requires pushing joystick to the side, which is not a natural movement for rats.

Current Design
The previously discovered problem led to our current design (since Fall 2018), which relies on the rat's natural ability to grasp bars, enabling the completion of a simple circuit to move the car to the corresponding direction. With this design, they are able to go forward and also steer the car in a more natural way. The current robot car was built following the instruction of Smart Robot Car Kit v3.0. A plastic container was attached to the base of the car with Velcro as the body of the vehicle. The car was programmed with Arduino to be able to turn left, right, and move forward when the rat stands on the metal plate and touches the corresponding wires to close a circuit.



Procedure Outline

Stage 0 – Habituation *denotes current stage in research
Stage 1 – Reinforcing touches
Stage 2 – Reinforcing movement
Stage 3 – Reinforcing movement to a certain distance
Stage 4 – Reinforcing turning right
Stage 5 – Reinforcing turning right from a certain angle
Stage 6 – Reinforcing sequencing of events (turn right, forward to treat tree)
Stage 7 – Adding distance of forward movement in event sequencing
*Stage 8 – Experimental procedures

Results

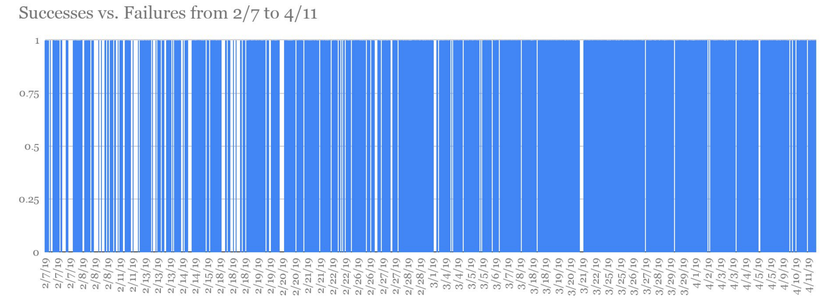


Figure 1. *The frequency of failed trials (in which a rat failed to drive the car towards the target and obtain a treat either by driving off course or remaining idle for longer than a minute) significantly decreased between the first week of the sequencing stage and the ninth (most current) week. The rats went from a 32.3% success rate to 67.1% within these nine weeks.*

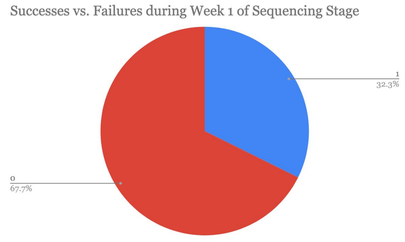


Chart 1. *The percentage values of successful (32.3%) and failed (67.7%) trials during the first week of sequencing.*

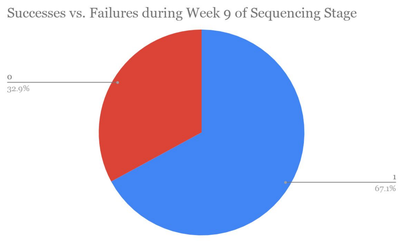


Chart 2. *The percentage values of successful (67.1%) and failed (32.9%) trials during the final week of sequencing.*

Discussion

Using our novel method and specialized car, we were able to successfully teach six female rats how to sequence together previous behaviors which they were taught through operant conditioning. Throughout the sequencing stage, the percentage of successful trials increased, while the percentage of failed trials decreased. Though statistical significance has not been determined, this switch in failures to successes over time is even more compelling because distance was systematically added throughout, compounding the difficulty for the rats to perform the task.

We would also like to note the additional compelling observation of how the rats were able to generalize the behaviors they were taught. This is evident in their utilization of left turns, though we never specifically reinforced the rats for turning left. Current experimental procedures are underway to attempt to test more empirically the behaviors which we have observed.