Decision-Making and Path Planning for Jumping Rats

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I. Introduction

Robots are often made more successful when they embody principles of animal locomotor dynamics and control. Analyzing the decision-making and real time path planning processes of animals holds promise in improving the navigational abilities of robots. Though there have been many studies of rats performing such decision-making, they typically have involved comparatively simple biomechanics, e.g. navigating a T-Maze or even a simple rectangular box. There have been far fewer studies of rats performing decision-making for challenging locomotor behaviors in 3D environments, such as jumping and climbing. Ultimately, we plan to understand how such complex behavior is influenced by the activity of neurons in the hippocampus, a region of the mammalian brain involved in spatial cognition [1].

To examine decision-making in complex locomotor behavior, we designed a stadium-style track for rats with two ditches with adjustable depth and length (Fig 1A). When a rat approaches a ditch, it is faced with a choice: climb down into the ditch and back out on the other side ("ditching") or jump over the ditch ("jumping," Fig 1B). Our goal was to analyze the factors that influence rats' decisions to either jump or ditch at any given ditch length.

II. Methods

All experiments were reviewed and approved by the JHU Animal Care and Use Committee. We performed preliminary experiments using a single animal, and additional animals are being trained. Prior to experiments, rats are trained to circumnavigate the track, crossing the ditches to get a food reward, regardless of choice.

In *Experiment 1*, we fixed the depth of the ditch and increased its length in increments of 1-inch and then reversed the process, decreasing the ditch length by 1-inch decrements. The animal performed several jumps at each length. In *Experiment 2*, we randomized the ditch length after each lap in order to challenge the animal to perform real time decision-making.

III. Results

Experiment 1. When the gap was increased and decreased incrementally, we found that the rat's behavioral decision was highly influenced by its most recent choice. This history dependence produced a hysteretic psychometric tuning curve: the decision function was dramatically different for increasing vs. decreasing ditch lengths (Fig 1C).

Experiment 2. We hypothesized that the hysteretic effect would be substantially reduced by randomizing the gap widths, owing to increased deliberation needed during decision-making. Our preliminary data supports this hypothesis (Fig 1D) and additional analysis (not shown) shows that history dependence is substantially reduced.

IV. Outlook

This behavior presents an opportunity to study many unknown aspects of navigational decision-making in animals. Some neurons in the hippocampus, called place cells, are active when an animal is at any location in the environment [1]. When faced with a decision, animals often makes head movements known as vicarious trial and error (VTE) behavior; sequential firing of place cells during this behavior has been shown to correspond to possible paths that the animal is planning to traverse [2]. Neurophysiological study of place cells in our jumping and ditching experiments could provide insights into animals' real time path planning for complex locomotor behavior.

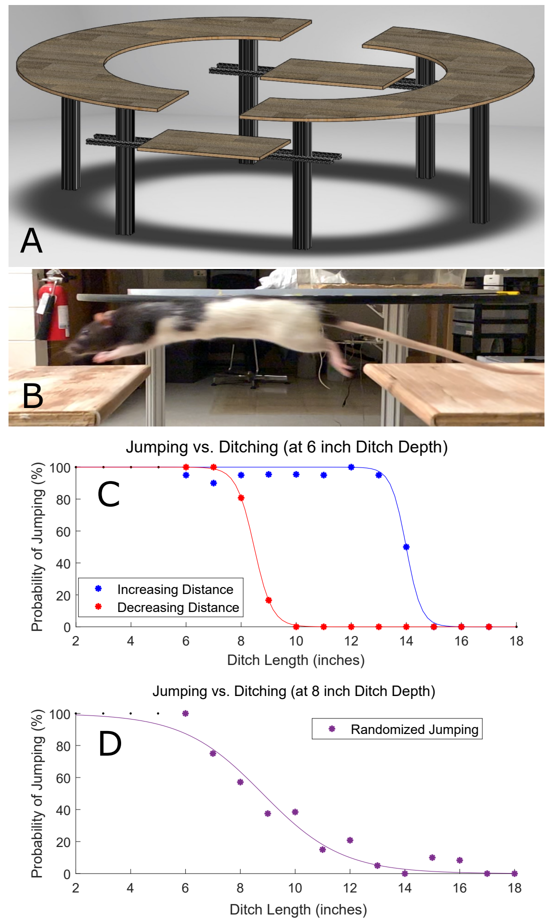

Fig. 1: (A) Stadium-style track for rats. (B) Rat jumping over a ditch. (C) Hysteresis: psychometric plots for probability of jumping at increment ditch length increase and decrease. (D) Psychometric plot for probability of jumping at randomized ditch length.

References

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