

# SIMPLE ARM EXPLORATION

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## 1. OVERVIEW

1.1. **Objective:** For learning songs tutored by adult birds, juvenile songbirds use two neural pathways in tandem. While one seems to work on the principles of Hebbian learning, the other pathway has been said to be based on reinforcement learning. Our aim here is to show, using a simple toy model, that the early onset of the reinforcement learning based pathway (before the HL pathway), provides an advantage in vocal learning, when compared to the simultaneous onset of both pathways.

1.2. **Paradigm:** We have a two-segment arm, free to pivot  $360^\circ$  around a point. A target is provided within the reach of the arms. The first arm is trained solely on RL, while the second arm is trained using both pathways.

## 2. TRAINING

Angles are initialised randomly. In each trial, noise is introduced directly to the angles. The error w.r.t to the the new position is computed. The RL pathway compares the new reward with its expectation, and updates the weights accordingly. The other pathway tries to minimise the difference between the actual output and the output of the sole pathway.

$$(1) \quad \text{angles}_t = (\text{angles}_{hl} + \text{angles}_{rl} + \xi)$$

$$(2) \quad \text{pos} = \text{cumulativeSum}(\text{lengths} * \cos(\text{angles}_t), \text{lengths} * \sin(\text{angles}_t))$$

$$(3) \quad E = ||\text{pos} - \text{Target}|| / \text{Output\_range}$$

$$(4) \quad R = e^{f(-E)}$$

$$(5) \quad \Delta angle_{hl} = \eta_{hl} * (angles_t - angles_{hl})$$

$$(6) \quad \Delta angle_{rl} = \eta_{rl} * (R_{curr} - \bar{R}_{prev}) * noise$$

### 3. RESULTS

For each target, simulations are run on three conditions: solely RL, early RL pathway, simultaneous learning. A sample result is shown below.

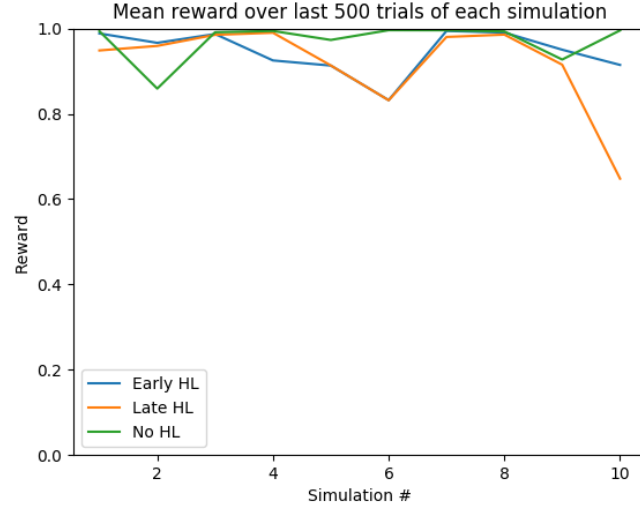


FIGURE 1. Overall results

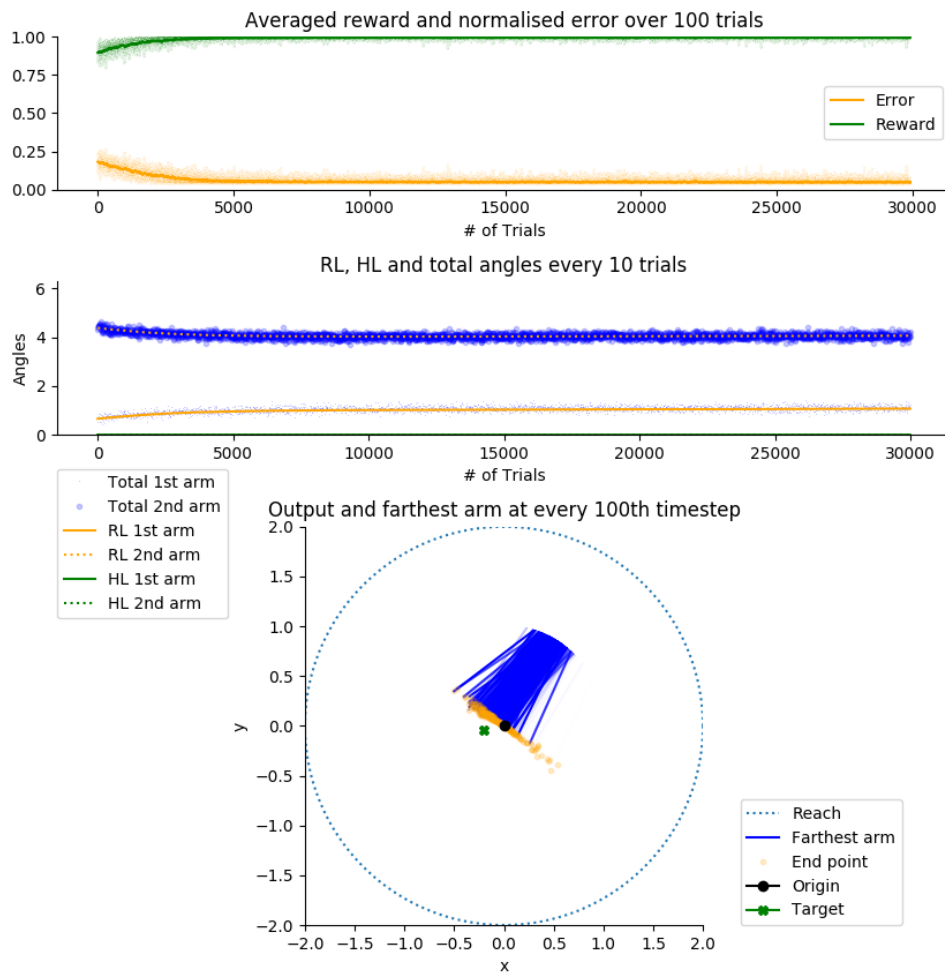


FIGURE 2. solely RL

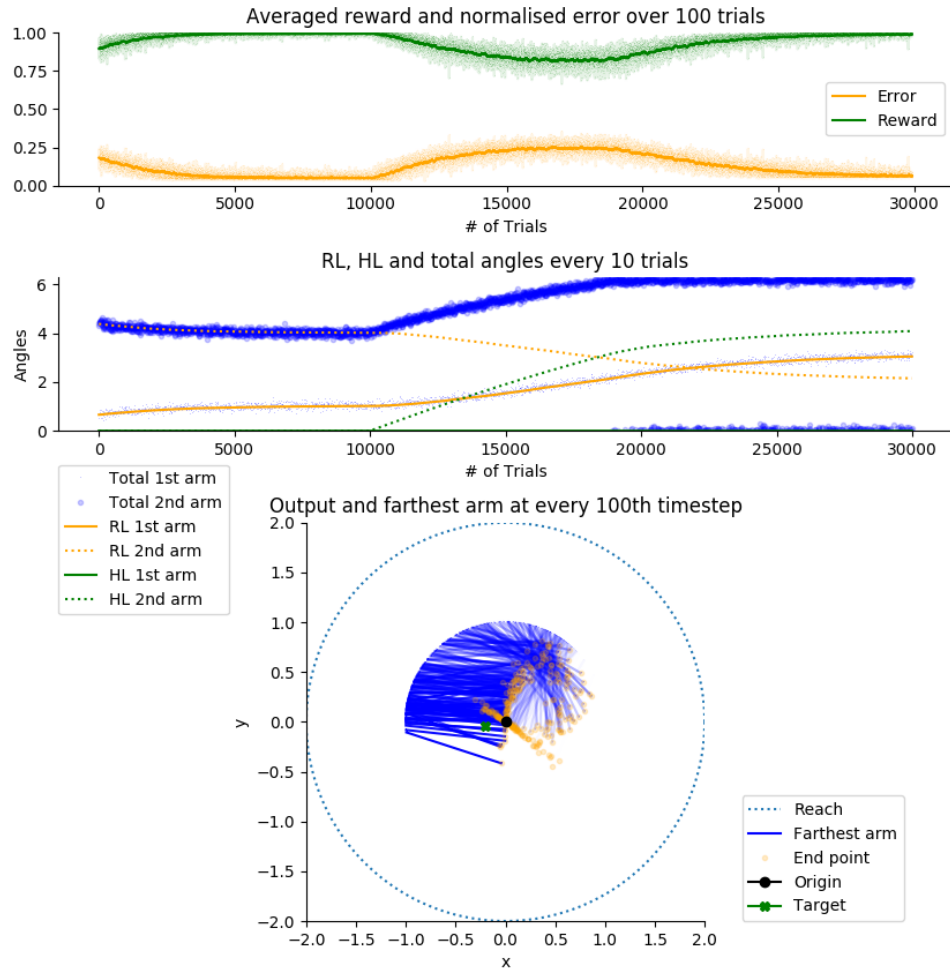


FIGURE 3. early RL pathway

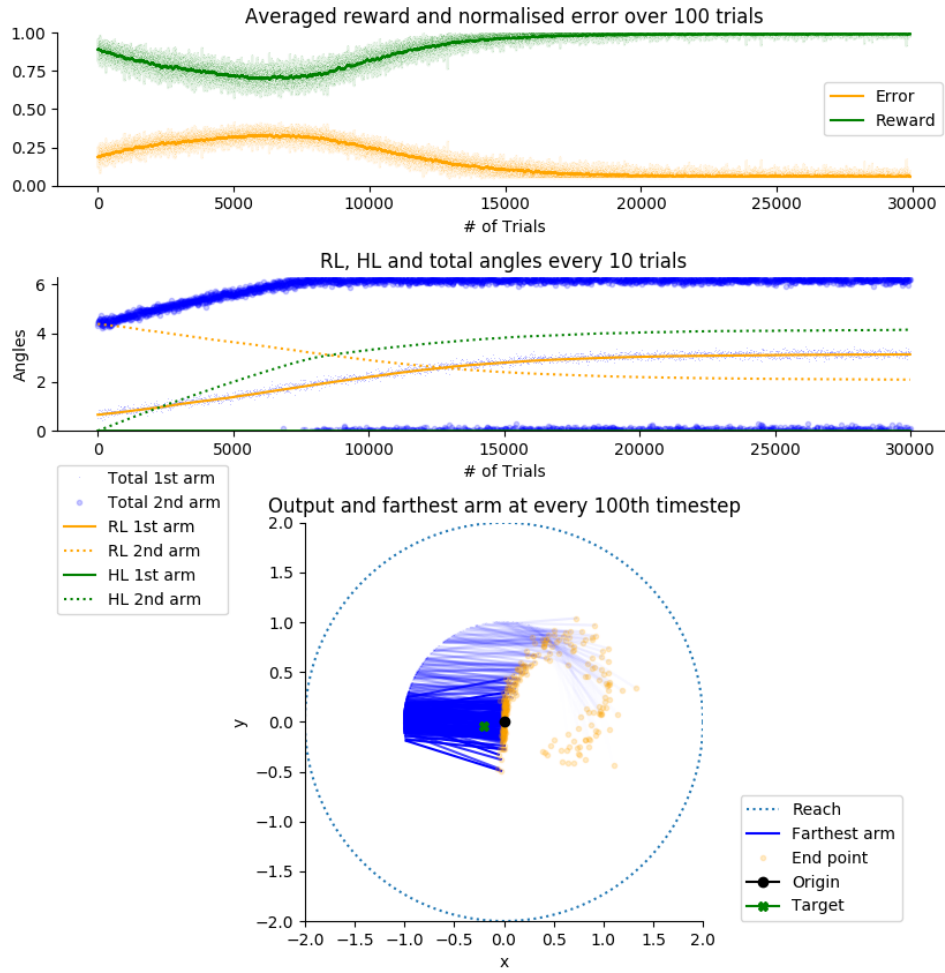


FIGURE 4. simultaneous learning