

ASSIGNMENT 6 — DECISIONS, LEARNING, AND COST FUNCTIONS

For all questions below, provide all programming code and plots in the report. Total marks (undergrad 27 | graduate 43).

Decision-Making

1. Plot token movements for the Bias For and Bias Against token patterns shown in the lecture. 1 mark.
2. Plot $p(R|N_R, N_I, N_C)$ for the Bias For and Bias Against token patterns. 1 marks.
3. Plot the current evidence (E) by discretizing $p(R)$ over time (step size: $h = 0.001s$). 1 mark.
4. For the drift-diffusion model with leak, set $g = 1500$, $L = 0.5$, $N = \mathcal{N}(\mu = 0, \sigma = 0.0)$, $T = +500 \& - 500$, $h = 0.001$, $DV_0 = 0.0$. 6 marks.
 - a. Plot the decision variable or the Bias For and Bias Against token patterns. 4 marks
 - b. What time (ms) does the decision variable cross the threshold for both simulations? 1 marks.
 - c. Rerun the drift diffusion model 10 times and plot the decision variable for each token pattern, but this time include noise ($N = \mathcal{N}(\mu = 0, \sigma = 3.0)$). 1 marks
5. For the urgency gating model with low pass filter, set $g = 1000$, $\tau = 0.05$, $N = \mathcal{N}(\mu = 0, \sigma = 0.0)$, $T = +500 \& - 500$, $h = 0.001$, $EV_0 = 0.0$. **(Graduate Only)**. 6 marks.
 - a. Plot the decision variable or the Bias For and Bias Against token patterns. 4 marks
 - b. What time (ms) does the decision variable cross the threshold for both simulations? 1 marks.
 - c. Rerun the urgency gating model 10 times and plot the decision variable for each token pattern, but this time include noise ($N = \mathcal{N}(\mu = 0, \sigma = 0.7)$). 1 marks
6. Additional questions to be answered independently. (3 marks | 5 marks)
 - a. What are classic decision-making phenomena?
 - b. Why does the drift diffusion model predict different decision times for the bias for and bias against token patterns?

- c. Why does the urgency gating model predict the same decision times for the bias for and bias against token patterns?
- d. Do you think task selection and a movement control policy are separate? (**Graduate Only**)
- e. Do movements reflect deliberation or decisions? (**Graduate Only**)

Learning

One-State Model (6 Marks)

7. Let us assume a participant is performing a visuomotor rotation task. There are 50 baseline trials without rotation, then 50 adaptation trials with a 30° rotation, followed by 50 washout trials with no rotation.

- a. Assume only an adaptation rate ($B = 0.2$). Plot the adaptation and error curves. 3 marks.
- b. Now include a retention rate ($A = 0.98$; $B = 0.1$). Plot the adaptation and error curves. 1 mark.

8. A participant performs 25 baseline trials without rotation, then 75 trials with a 30° rotation, 10 trials with a -30° rotation, followed by 40 washout trials with no perturbation. Assume $A = 0.98$; $B = 0.1$.

- a. Plot the adaptation and error curves. 1 mark.
- b. Assume the following are clamp trials: [27, 36, 45, 53, 62, 71, 80, 89, 98, 110-150]. Plot the adaptation and error curves. 1 mark.

Two-State Model (3 marks | 6 marks)

9. A participant performs 25 baseline trials without rotation, then 75 trials with a 30° rotation, 10 trials with a -30° rotation, followed by 40 washout trials with no perturbation. Assume $A_s = 0.998$, $B_s = 0.049$, $A_f = 0.597$, $B_f = 0.227$.

- a. Plot the fast state (X_f), slow state (X_s), net adaptation (X_{net}), and error. 2 marks.
- b. Assume the following are clamp trials: [27, 36, 45, 53, 62, 71, 80, 89, 98, 110-150]. Plot X_f , X_s , X_{net} . 1 mark.

10. Fit the two-state model to X_{net} from **3b** above. Make your initial parameter guesses as follows: $A_s = 0.994$, $B_s = 0.025$, $A_f = 0.521$, $B_f = 0.268$ (**Graduate Only**):

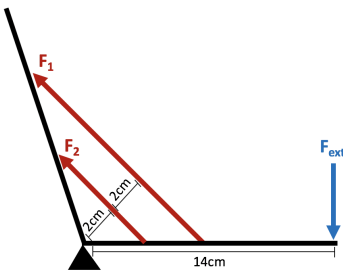
- a. Plot X_f , X_s , X_{net} from the best-fit parameters, and list the best-fit parameters. 3 mark.

11. Additional learning questions to be answered independently (3 marks | 5 marks).

- What is a real-world example of generalization made by the motor system (other than the example in class)? 1 mark.
- What type of error will the nervous system most likely store? 1 mark.
- Why is motor variability more important in reinforcement learning than error learning? 1 mark.
- What are reasons we do not fully adapt? **Graduates Only.** 1 mark
- How many timescales of adaptation are there? **Graduates Only.** 1 mark

Cost Functions

12. Predict muscle activation by minimizing the sum of (muscle force)². Assume $F_{ext} = 75N$, a muscle stress of 35, and a PCSA of 10 for both muscles. Interpret the result. 3 marks



13. Additional learning questions to be answered independently (3 marks)

- What are cost functions trying to resolve and how do they provide insight into the nervous system? **Graduates Only.** 1 mark
- Optimal Feedback Control uses multi-objective optimization. What is OFC minimizing when it is used to model reaching towards a target? **Graduates Only.** 1 mark
- According to Daniel Wolpert, what is the sole purpose of our brain? **Graduates Only.** 1 mark