Neural Modelling exercise 2: Prediction learning

Hand-in by **Friday, 8.11.24 (midnight)** to neuralmodelling24@gmail.com

If you are handing in as a two person team, make sure to put both of your names on your solution (please hand in only one report per team). Besides your responses to the questions in text form, your submission should contain your code. You could e.g. link to a Github repo or submit your report as a Jupyter notebook.

Conditioning (Lecture 2)

- Simulate data for each of the following conditioning paradigms:
  - Blocking
  - Inhibitory conditioning
  - Overshadowing
  - Secondary conditioning
  - Explaining away

  To do this, generate arrays which correspond to the sequences of presented stimuli and the sequences of presented rewards (ignore time within a trial for this, each entry is one trial). Also generate an idealised sequence of expectations of rewards of the animal (the expectation occurs after the presentation of the CS but before the potential presentation of a reward).
- Now use the Rescorla-Wagner rule to learn these expectations, based on the stimulus and reward vectors you generated.
- For which paradigms do your learned expectations qualitatively agree with your idealised predictions? For the non-matching paradigms, speculate why the Rescorla-Wagner rule failed to produce the correct expectations.

Extinction (Lecture 3)

In an extinction protocol, animals repeatedly encounter a previously learned CS, but without receiving the corresponding punishment. However, in certain conditions, the learned association can resurface. We will work towards one way of modelling this, using state-based inference. (Remember: A state, or latent cause, is the context which an animal infers to make predictions about its environment.)

- An animal first encounters 50 conditioning trials in a row, then, on the next day, 50 extinction trials in a row. Finally, after a substantial delay of 30 days, it encounter the CS again, for one single trial. Design an appropriate array which could describe the belief of the animal about the current state of the environment on each trial, right before receiving the CS. (Hint: How many states do you need? At which points in time do they change?)

- Using this belief array, plot the animal's expectation of receiving the US after the CS on each trial. (For this part of the exercise, ignore the learning of the CS-US relationship, assume that the animal perfectly knows the connection between CS and US for each state).

- Now, rather than assuming our state belief array, we will infer it ourselves with a simple heuristic. Write a function which takes three inputs: The state of the previous trial, the similarity of the previous trial to the one before it in terms of made observations, and the amount of time which passed since the last trial. Based on these arguments, return a belief over all states which are under consideration. On the first trial, the animal is 100% certain of being in state 1. (We don't expect any specific functional form for this function, but it should qualitatively recreate your belief array from the first part of this exercise).

- Finally, maintain a learned association strength between CS and US for each state separately. Update them after each trial according to the Rescorla-Wagner rule, but also weigh the magnitude of the update by the strength of the belief in the state. For simplicity, assume that the belief about the current state does not change between the beginning and the end of each trial.