PSY 5939-U06: Introduction to Computational Cognitive Neuroscience
Homework #6: Predicting a BOLD response

In this exercise, you will use some of the reward prediction error (RPE) values that you computed in Homework #5 to generate predictions of the BOLD response that should be observed in a brain area that computes those RPEs. You should submit your results as **a single jupyter notebook** via email. Separate the different questions with titles by inserting a markdown cell and then typing "# Question 1", "# Question 2", etc, and running the cell. Your explanations of results and answers to questions should be included in **markdown cells** (not as comments) within the notebook.

The "neural activity" values that you will use as an input to the linear model of the BOLD response are the first 50 RPEs computed in point #2 of Homework #5 (the simulation in which you trained your network using reinforcement learning). In that homework, you used the function `print_trial_info` to print the values of these RPEs in each trial, so you can simply copy the values directly from your previous jupyter notebook.

The steps that you should follow to create the BOLD predictions are exactly the same as those followed in Programming Tutorial #8; the slides from that tutorial can be found here. In that tutorial, there was a single value of activity per trial, which was extended in time for 500 ms. Here, too, you have one RPE for each trial.

You should create predictions for an experiment with the following parameters:

- There is a waiting period of 10 seconds before the first reward is presented and the first RPE is computed.
- When a reward is presented, the RPE is computed by some population of neurons. The population's "neural activity" is equal to the value of the RPE, and it lasts for $500ms$.
- The period of time from the end of one RPE to the beginning of the next RPE should be 5 seconds. This is rather unrealistic for a real fMRI experiment, in which the time between rewards is affected by response times and the ITI is varied randomly (i.e., trials are "jittered"). However, as we saw in Programming Tutorial #8, this regular spacing of trials makes things easier to program and this is just a learning exercise after all.
- After the last reward (and RPE-related activity), the experiment keeps going for another 30 seconds without anything happening.
- You will have to figure out the duration of the experiment yourself, but this is quite easy (early waiting period + 50 RPEs + 49 ITIs + final period).
- The TR is 2 seconds.
- Your "neural activity" array should be created in steps of 50 ms (as in the tutorial).

1. Create a prediction of the BOLD response using a double-gamma HRF. As in the Programming Tutorial #8, you should:

(a) Plot to screen the predictions of activity together with the predicted BOLD response (same plot), using the timescale of the model's predictions (i.e., steps of 50 ms).

(b) Plot to screen the predicted BOLD response, using the final sub-sampled values (i.e., steps of TR).

(c) Save in a text file the `activity` array (in steps of 50 ms) and also the final predicted BOLD response (in steps of TR).

2. Create a prediction of the BOLD response using a single-gamma HRF. To do this, simply use the first gamma from the previous point, without subtracting the second gamma. Do the following:

   (a) Plot to screen the predicted BOLD response, using the final sub-sampled values (i.e., steps of TR), and answer the following question: How much of a difference do you see in the predicted BOLD response when using this single-gamma HRF, compared to the predicted BOLD response observed earlier with the double-gamma?

   (b) Compute the Pearson correlation between the BOLD response predicted with the single-gamma HRF and the double-gamma HRF, and print it to screen. Are the two predictions similar or dissimilar? Do you think that the choice of HRF would make a big difference in the results of a model-based fMRI data analysis, considering that observed BOLD responses would be noisy?