Project 3: Perceptual bistability

1) Implement a simple model of perceptual bistability consisting of two recurrently connected neurons each receiving input from one eye: $I_L(t) = w_L\, x_L(t) + w_R z_R(t)$, where $I_L(t)$ is the input current to the neuron tuned to the left eye, $w_L\, x_L(t)$ is the feedforward input from the left eye weighted by synaptic strength $w_L > 0$ (sensory excitation), and $w_R z_R(t)$ is the recurrent input from the neuron tuned to the right eye weighted by synaptic strength $w_R < 0$ (lateral inhibition). For simplicity, simulate the model in discrete time, assuming that the spiking probability is a logistic sigmoid function of the input current. Illustrate the behavior of this model in a binocular rivalry experiment.

2) Show how this model can be interpreted in terms of Gibbs sampling (see Gershman et al., 2012 for reference, though that paper uses a more complex model). Hint: the spiking probability here can be understood as a conditional distribution.

3) A key signature of approximate Bayesian inference through sampling is that variability reflects uncertainty. Show how changes in input strength (e.g., corresponding to different image contrast levels) produces different sampling dynamics. What do these dynamics tell us about uncertainty representation in the visual system?

4) How does the relative strength of sensory excitation and lateral inhibition affect rivalry dynamics? Discuss how this is related to the findings from Robertson et al. (2016).

References:

Gershman, S.J., Vul, E., & Tenenbaum, J.B. (2012). Multistability and perceptual inference. *Neural Computation, 24*, 1-24.

Robertson, C. E., Ratai, E. M., & Kanwisher, N. (2016). Reduced GABAergic action in the autistic brain. *Current Biology, 26*, 80-85.