Quizz 5 NAME

1) Neurons in cortical structures are thought to be active during working or short term memory tasks even after the stimulus they respond to is OFF. Describe briefly in your own words and draw schematic diagrams for two possible mechanisms,. one at the single cell level and one at the network level, to maintain persistent firing in a neuron in the absence of outside stimulation.

At the single level, a mechanisms called after-depolarization could lead a neuron to stay active after the stimulus is off. Basically, with every spike Ca+ increases inside the cell and Ca activates a Ca+ dependent Na+ channel. The accumulation of calcium and the channel have very slow time constants, leading to a long lasting depolarization and spiking activity after the stimulus is off. One can think of this as a neuron with a positive feedback onto itself.

At the network level, if neurons are connected to each other in a positive feedback loop, and the synapses are relatively slow, then the network can stay active even after the stimulus is gone.

2) Consider the diagram below. Neurons in this excitatory feedback network are driven into a stable attractor by a short, transient stimulus.

a) Considering the activity you see in the graphs after a short stimulus presentation in I1, explain which pattern has been stored in an attractor memory?

b) Synapses between which neurons have to be strong to produce this result (you should assume that the neurons do not have the intrinsic properties to keep them active in isolation, i.e. the network is necessary to produce sustained firing).

c) You want to make sure the attractor state ends after a few hundred milliseconds (that means, the neurons stop firing after a few hundred milliseconds). Suggest two mechanisms, one that involves an intrinsic mechanism for each neuron and one that involves adding to the network that could achieve this. Write down appropriate equations for each mechanism.



1. The pattern that has been stored is n1 and n2.
2. Synapses have to be strong enough to overcome the neurons’ firing thresholds.
3. An intrinsic mechanism is a calcium dependent K+ channel or an afterhyperpolarization. In that case, with every spike the neuron starts slowly inhibiting itself until it stops firing. You could use the following equations (not the only ones possible):

T dc/dt + c = alpha \* x(t) with T being the time constant for Ca+ acculmulation, c the levels of calcium, alpha a parameter and x(t) the spike of the neuron.

Then replace v(t) by v(t) – u\*c(t) in the membrane voltage equation, u being a parameter. This makes it so that the neuron slowly inhibits itself.

A network addition could be an inhibitory neuron with a relatively slow synapse to reset all the neurons.

3) Create a two layer self-organizing network with three neurons in each layer. Using small (~0.1) initial synaptic weights between all neurons in layer 1 and all neurons in layer 2, calculate the following steps: (a) activate two neurons in layer 1, (b) find the resulting activities in layer 2, (c) apply a winner take all scheme in layer 2 and calculate the new activation values for layer 2, (d) apply a hebbian learning rule to the synaptic weights to calculate new synaptic weights. For each step, show the equations you are using.

Assuming neurons are linear. Inputs are 1.0, all weights are distributed between 0.08 and 0.12



4) Now use the same network with the same original small random synaptic weights. Activate neurons in layer 1 with the same pattern you used in 3) and neurons in layer 2 with a pattern of your choice. Apply a hebbian learning rule and calculate the new synaptic weights.



5) Explain the difference between what you are doing in 3) and in 4).

3) is a self-organizing system in which activity is only imposed on layer a and “self-organizes “ in layer b. 4) is heteroassociative in which activity is imposed on both layers.