Bi150 Problem Set 4

Due: Tuesday, November 15th at 4:30 P.M.
At the "Bi 150 Box"
3rd floor of Kerckhoff in front of Room 326

(The building may be locked after 5 P.M.)

INSTRUCTIONS

Please:

1) Turn in your work with this cover page.
2) Use separate sheets of paper for the answer to each question, so that grading can proceed in parallel
3) Write or type your answers neatly.
4) Put your name on each page of your answers.

Name: ______________________________
Section #: ______________________________
Mail Code: ______________________________
TA Name: ______________________________
Date and Time turned in: ______________________________
Number of pages including this one:______________________________

There are 2 questions.

Grade and Comments:
1____________________
2____________________

Total: _______________

Problem 1. Vision (1.5 points)

A. (0.6 point) Visual impairments

a. Match each visual impairment listed below with a single lesion or mutation in the visual system that could be responsible for it. You should not use the same lesion/mutation twice.

b. For each pair you have determined in part **a.**, explain briefly what is known about how the given lesion produces the specified visual impairment.

Visual impairment:

(i) Complete loss of vision only in the temporal halves of both visual fields.
(ii) Complete loss of vision only in the superior quadrant of the visual field on the right side. The central area is unaffected.
(iii) Inability to perceive a pattern of bright and dark bars that have both low spatial frequency and high temporal frequency.
(iv) Inability to see or dream in color.
(v) Difficulty to adapt to different light intensities quickly.
(vi) Inability to reach accurately for visual objects in space.

Lesion/mutation:

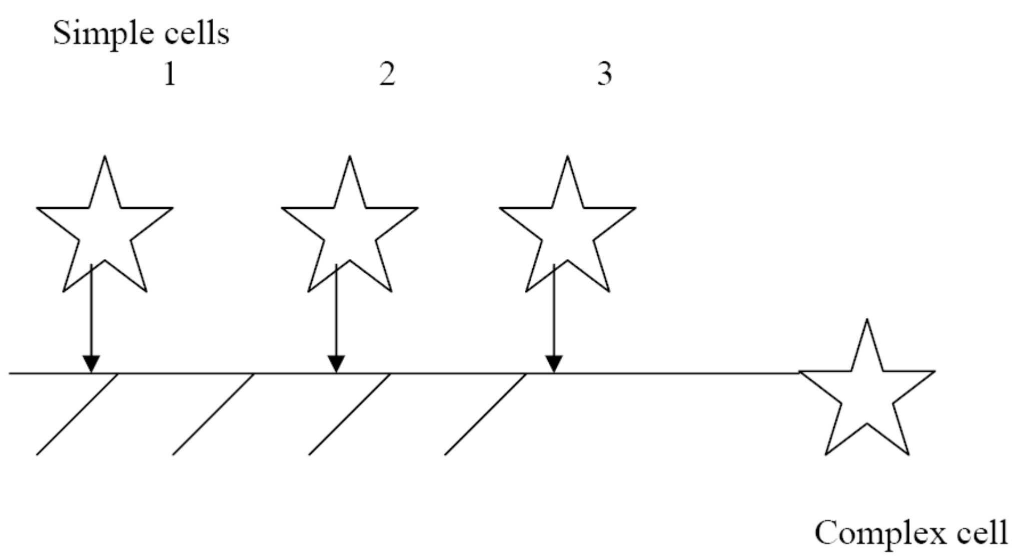
(a) Loss of rods.
(b) Bilateral and complete lesion to a large region of temporal cortex, including all of cortical visual area V4.
(c) Lesion of the lower bank of the calcarine sulcus in the left hemisphere.
(d) Mutation causing a selective loss of function of parvocellular ganglion cells in both retinae.
(e) Selective and complete loss of cones in both retinae.
(f) Complete saggital transection of the optic chiasm (cutting only those fibers that would normally cross there).
(g) Bilateral lesion in the posterior parietal lobe.
(h) Mutation of cGMP-gated channels in the retina causing selective impermeability to Ca^{2+}
(i) Mutation and selective loss of function of magnocellular ganglion cells in both retinae.
(j) Mutation of cGMP-gated channels in the retina causing selective impermeability to Na^{+}.
(k) Lesion of the optic radiation fibers that curve into the temporal lobe in the left hemisphere.

B. (0.9 points) Simple and Complex cells

a. A simple cell responds to bars of light with a specific orientation. Draw a network of on or off center ganglion cell inputs to a simple cell that would enable it to respond to this stimulus. Draw the receptive fields of each ganglion cell needed, and the spatial relationship of these receptive fields. In a few sentences explain how your model is supposed to work.

b. A complex cell responds to bars of light with a specific orientation. Unlike the simple cell, the receptive field of a complex cell is generally larger and the position of light bars in the receptive field is not critical in order to evoke the response in the neuron. It is believed these properties of complex cells are derived from their inputs from multiple simple cells. Draw a neuronal network of multiple simple cells (with different receptive fields) connecting to a complex cell to enable the larger receptive field and orientation tuning properties in this complex cell. In a few sentences explain how your model is supposed to work.

c. Furthermore, a complex cell can also respond selectively to unidirectional movement across its receptive field in a specific orientation (e.g. a horizontal light bar moving upwards). This could also be explained by the connectivity between multiple simple cells to one complex cell. In a neuronal network shown below, three simple cells (with different receptive fields) form synapses onto a complex cell at different locations on one long dendrite. This complex cell is more sensitive to a light bar moving from the receptive field of simple cell 1→2→3 but not a light bar moving in the opposite direction. Explain how this direction specificity might achieved using what you know about electrophysiology.



Problem 2. The Auditory System (1.5 points)

A. Neural sensory map

The delay in time between a sound reaching one ear and the other is used to localize sound. One neuronal model for measuring this auditory delay is diagrammed below. Lines from input ear to binaural cell represent the length of neuronal axons.

a. **(0.4 point)** Describe the general mechanism by which the neurons shown in this model distinguish between sounds coming from sources at different locations.

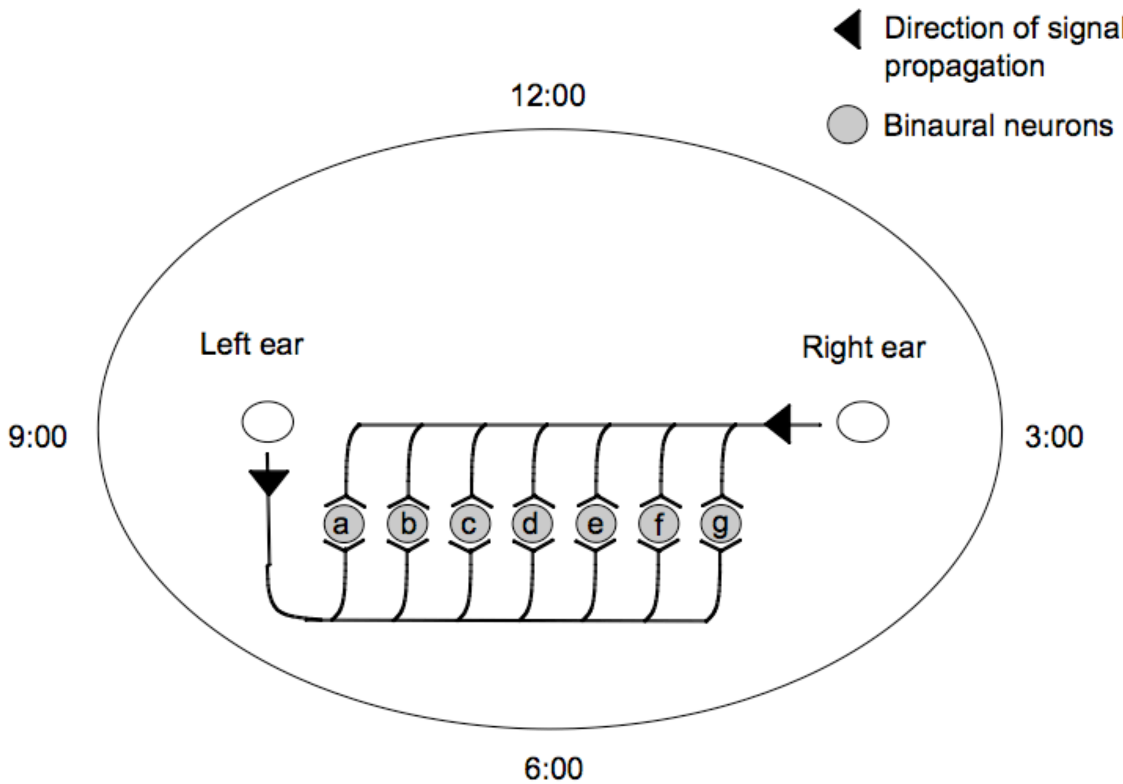
For parts **b**, **c**, & **d**, refer to the figure below. **(0.1 point each)**

b. Which of the neurons (**a** through **g**) would respond to a sound located immediately above the diagram (at 12 o'clock)? Hint: use a ruler.

c. What are the possible locations of sounds that neuron **a** would respond to? Use clock coordinates with accuracy within the ½ hour (i.e. 2:00 differs from 2:30). Assume that sound travels from the source of sound to the ear at the same average speed that the information is transduced and transmitted in various steps from the ear drum to the binaural cell.

d. What are the possible locations of sounds that neuron **b** would respond to? Use clock coordinates with accuracy within the ½ hour.

e. **(0.3 point)** The binaural neurons in this model are arranged in the brain so as to form a map. You have read about tonotopic maps in the auditory pathway. Mention two ways in which this map differs from a tonotopic map.



B. Tuning curves

f. **(0.2 point)** Draw two sets of tuning curves for neurons **a** and **b** (from the figure above), plotting electrical activity against clock coordinates. Draw the first set of tuning curves assuming that there is some overlap in the receptive fields of **a** & **b**. Draw the second set of tuning curves such that overlap between their receptive fields would be minimized.

g. **(0.3 point)** What is the name of the neuronal network feature could you add to the diagram to enable better two-point discrimination (i.e. the actual tuning curves will look more like the second set you have drawn than like the first set)? (Hint: it consists of two words). Explain briefly how this would achieve better two-point discrimination.