

Bi150 2011 Problem Set 5

Due: Tuesday, November 22th 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 3 questions.

Grade and Comments:

1 _____

2 _____

3 _____

Total: _____

Problem 1. Measuring Brain Activity (1.5 points)

Brain Measurement Techniques

fMRI
EEG
PET
Patch-clamp (microelectrode recording)
Light microscopy
Lesion

A. (0.3 point) Rank in order the above brain measurement techniques in terms of their spatial resolution, from lowest (1) to highest (6), with which they can measure brain activity (directly or indirectly).

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.

B. (0.3 point) Rank in order the above techniques in terms of their temporal resolution, again from lowest (1) to highest (6), with which they can measure brain activity (directly or indirectly).

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.

C. (0.4 point) Pick the one measure that provides the strongest causal evidence that a given brain region is necessary for a particular function. Give a brief explanation for your answer.

D. (0.5 point) Functional MRI is used to make claims about neuronal activity in different parts of the brain. However, it does not directly measure electrophysiology. Briefly describe what physiological parameter(s) fMRI actually measures, and how this measurement is thought to be related to neuronal activity.

Problem 2. Sensorimotor System (1.5 points)

A. (0.3 point) Even with our eyes closed, we generally still know where our arms and legs are located.

- a. How can we tell the body's position without looking? Name the sensory modality used for this and briefly describe the peripheral mechanism for sensing it.
- b. Describe the most relevant pathway from sensory neurons to the sensory cortex that mediates the sensory modality in part a. State each stage of synapse as you trace the pathway from the periphery to cortex. (Alternatively, you can draw a diagram with the pathway, and clearly label the stages of processing). Given the specific names of the structures involved at each stage of processing (e.g., "auditory cortex" could be a correct label, but "cortex" is not), and state if any pathway crosses to the other side of the body or brain.

B. (0.4 point) A two-point discrimination test examines our ability to discriminate touch from two different points versus one point.

- a. Which part of the body would be most sensitive for this discrimination?
- b. How can this fine sensitivity be achieved? Describe two distinct features/mechanisms that contribute to better two-point discrimination.

C. (0.4 point) A doctor started an examination of a patient who had a complete section (lesion) on one half side of the spinal cord only at the L1 level. The patient has paralysis in his left leg.

- a. Which side of the spinal cord is damaged? Explain a relevant pathway for the paralysis of this patient.
- b. Next, the doctor examined whether the patient can feel pain at each part of his body. Does the patient have a problem for sensing pain? If so, explain which part of his body has this defect and describe a relevant pathway.
- c. Finally, the doctor examined whether the patient can feel touching with a fine hairbrush at each part of his body. Does the patient have a problem for sensing this touch? If so, explain which part of his body has this defect and describe a relevant pathway.

D. (0.4 point) You have heard about 4 sensory systems in the lectures: vision, audition, olfaction and somatosensation. From your knowledge of the processing principles in these 4 systems, rank in order the four (from least to most) with a brief explanation in terms of:

- a. their best temporal acuity (how precisely in time they can tell apart the occurrence of stimuli)

- b.** their best spatial acuity (how precisely in space, or on the body, they can discriminate stimuli)
- c.** their relative importance to humans (the impairment to everyday life that would result from their loss)
- d.** the amount of primary sensory neocortex devoted to them in humans.

Problem 3. Olfactory System (1.5 points)

A. (0.25 point) Anatomy

Describe the major excitatory synaptic connections, beginning at the nose and ending in the cortex, in the main olfactory pathway of mammals.

B. (0.75 point) Olfactory receptor neurons (ORNs)

- a. Describe the intracellular signaling pathway in ORNs, leading from odor stimuli to action potentials. Answer in one paragraph, and explain the role of each molecule involved in this signaling cascade.

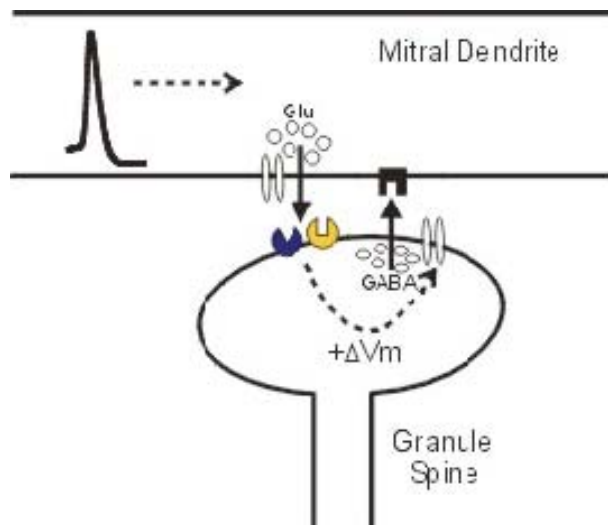
- b. Individual olfactory receptor molecules show relatively low affinity for a range of ligands. What would be the selective advantage of this broad spectrum of ligand binding? Explain your ideas considering each of the following situations:
 - i) two different concentrations of the same odor are applied sequentially

 - ii) two similar odors are applied sequentially

- c. The olfactory system of most animals has sensitivity on the order of a few odorant molecules. Yet we become less sensitive to the odor when exposed to it for a long time. Utilize your knowledge of GPCR pathways to describe a possible mechanism in ORNs that might contribute to this phenomenon.

C. (0.5 point) Functional circuit

There is a special type of synapse at mitral-granule cells (see the figure below and Kandel Figure 32-7, right hand panel.) At these synapses, glutamate vesicles release their contents from dendrites of mitral cells when these cells generate action potentials. The glutamate then activates receptors on the dendrites of granule cells. Depolarized dendrites of granule cells, on the other hand, release the contents of GABA vesicles, which activate GABA receptors on the dendrites of mitral cells. This is called dendrodendritic inhibition.



- a. Describe possible differences in action potential firing patterns of mitral cells with and without granule cells. Note that action potentials induced in mitral cells back-propagate into their dendrites.
- b. How does signal processing among multiple glomeruli differ functionally: dendrodendritic synapses vs the usual axodendritic synapses?