

## BI/CNS 150 FINAL EXAMINATION, 2011

### **You may read only this page before beginning the exam.**

This examination contributes *30% of your total course grade*. There are five questions in the exam, please answer four. (If you answer five, we will pick a random 4 of those to grade). The exam will be graded out of 30 points, 7.5 for each question. Please indicate clearly which questions you answered, and please be sure to answer each question on separate pages. This examination covers lectures and reading material through the entire course. This exam is *11 pages* long, including this cover page. Please make sure you have all the pages before you start.

**Four hours** are permitted for completion of the exam. Use the first 15 minutes or so to read all of the questions calmly and choose which four to answer. You may take one break up to 30 minutes (which does not count towards the 4 hour maximum), but during the break you are not allowed to refer to any material that could be helpful for the exam. Please be as succinct and clear as possible; if we are unable to read your answer, you will not get credit for it. If time expires, you may draw a line across the page and complete your answer. Credit *may* be given for answers completed in this manner, up to a maximum of 50% of the credit you would have received had the material been written within the allotted time. This mechanism is intended for completing answers with a relatively small addition of overtime material; it is not intended for answering an entire question after time is up.

*You may refer to lecture notes, this year's problem sets, and your textbook* to complete this exam. You may also use a calculator or computer, if desired. You may not collaborate or discuss questions or answers with anyone else before the exam due date. You may not use the Internet while taking the exam. If you feel that you need to make any further assumptions about any of the problems, feel free to write your assumption by your answer and the reason that you needed to make that assumption.

You must ***answer each question on a separate sheet of paper and write your name, page number, and question number on every sheet. Fill out this cover sheet and staple it to the front of your exam.***

Completed exams are due by *5:00 PM on Friday, December 9*. You may place them in the Bi 150 mailbox in front of room 326, Kerckhoff. Late exams will not be scored, unless you have a valid excuse from the registrar.

NAME: \_\_\_\_\_

Section: \_\_\_\_\_

Mail Code: \_\_\_\_\_

TA Name: \_\_\_\_\_

Date and Time turned in: \_\_\_\_\_

Number of Pages: \_\_\_\_\_

## **1. Learning and Memory (7.5 Points)**

A. (4 points total)

a. In the late 1800's, Ivan Pavlov performed an experiment in which dogs were taught to associate the sound of a ringing bell with the presentation of food, as described during lecture. The results of this experiment provided the first evidence for *classical conditioning*. **Briefly describe the experiment Pavlov performed and explicitly identify the conditioned stimulus, unconditioned stimulus, unconditioned response, and conditioned response. (2 Points)**

b. In lecture we also discussed another version of such an experiment, known as *Pavlovian fear conditioning* (Delay type, where the conditioned and unconditioned stimuli overlap in time), where subjects learn to associate a neutral stimulus, such as a square with blue color, with a painful stimulus, such as a shock to the hand. **What region of the brain is thought to participate in the formation of *Pavlovian fear conditioning*? Does the formation of this type of memory require NMDA type glutamate receptors? In humans, what other ways are there to acquire a conditioned fear response in this experiment, without actually experiencing the electric shock oneself? (1.5 Points)**

c. **How does *operant conditioning (instrumental learning)* differ from *classical Pavlovian conditioning* in terms of the associations being learned? Describe what is associated with what in each of these two forms of learning. (0.5 Points)**

B. (3.5 Points total)

a. The formation of long-term, declarative memories is thought to depend on the medial temporal lobes. Patients with medial temporal lobe damage, such as HM, are unable to form new declarative memories (*anterograde amnesia*). In addition, these patients cannot remember events from the time immediately before the damage occurred, but are able to recall events from the distant past (*graded retrograde amnesia*). **Explain the neurological basis underlying *graded retrograde amnesia*, focusing especially on the mechanism underlying its gradation. What component of learning and memory is taking place that accounts for the gradation? What neural structures are involved? (1.5 Points)**

b. The year is 1960, and you are a neurologist examining a patient whose medial temporal lobes were bilaterally surgically resected for the treatment of epilepsy. Resected areas include: all of the hippocampus, amygdala, parahippocampal cortex, entorhinal cortex, and perirhinal cortex. Listed below are 10 tests you run on this patient. **Assuming the patient was able to pass all of these tests before the surgery, indicate whether he can complete these tests after the resection by placing a mark under “Yes” or “No”. (2 Points)**

Tests	Yes	No
Ability to tie his shoes		
Displays a Flexor-Withdrawal Reflex		
Ability to hold 5 digits in working memory		
Ability to remember these same 5 digits 3 days later		
Ability to show <i>priming</i> (a type of memory)		
Learn to trace a pattern (such as a star) while looking in a mirror		
Ability to associate a tone with an electric shock to the arm		
Recall his mother's name		
Complete simple arithmetic		
Ability to show perceptual learning		
Significant decline in his intelligence quotient (IQ) following surgery		
Distinguish between fearful and happy facial expressions		
Feel joyful after winning the lottery		

## **2. Sensory systems (7.5 points)**

### A) Signal transduction in audition (3.0 points total)

a) Beginning with a sound wave reaching the tympanic membrane and ending with a receptor potential in the hair cell, describe the transduction of sound. Be sure to describe the steps by which sound is transmitted from the eardrum to the inner ear, the function of the basilar membrane, and the mechanism by which a receptor potential arises in hair cells (no more than two paragraphs). **(1.0 pts)**

b) Compare and contrast the inner and outer hair cells. Include their function, relative number and relative amount of innervation (both afferent and efferent). **(1.0 pts)**

c) Give two examples of mechanisms used in the auditory system to adapt to sounds with different loudness or to protect from potentially damaging sounds **(1.0 pts)**

### B) Sensory Receptors in the Somatosensory System (1.5 points total)

a) Give examples of two different touch receptors, one that is rapidly adapting, one that is non-adapting and describe their function. **(0.5 pt)**

b) Explain the advantage of having both rapidly adapting and non-adapting receptors. **(1.0 pt)**

C) Topographic maps (3 points total). As you know, sensory systems feature topographic maps of various kinds.

a) For the following sensory systems, state what is being mapped in the primary sensory neocortex **(1.0 pt)**. If there is more than one thing mapped, you only need to state one.

Audition:

Vision:

Somatosensation:

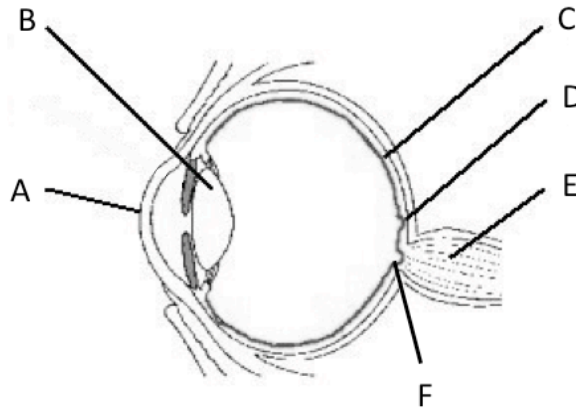
b) Pick two of the sensory modalities from part (a) above and briefly describe any distortions or magnifications in the maps that are seen in primary cortical regions **(1.0 pt)**.

c) Describe the functional advantage of the distortions/magnifications just described **(1.0 pt)**.

### **3. Visual System (7.5 points)**

#### **1. Organization of the Retina (3.5 points total)**

- A. Label the lettered parts of the eye in the following diagram (one or two words each; 2.0 points)**



- B. Use the structures/areas you identified in the diagram above to answer the following questions. A structure can be used more than once. Give both the letter and the name of the corresponding structure. (1.5points)**

1. Which area has the greatest visual acuity and why?
2. Which area corresponds to the point where the blind spot is located? What structure is found in this region?
3. Cells in which structure fire action potentials?
4. Cells in which structure produce graded potentials but not action potentials?

#### **2. Visual Pathways (3 points total)**

- A. Name the two main visual processing pathways that originate in the retina and continue through the LGN to the primary visual cortex. List 4 functional attributes that differ between these two processing streams.**
- B. Beyond primary visual cortex, there are also two broad processing streams through higher-order visual and association cortices. The names of these two streams refer to their**

anatomical location: name them, and indicate where they are roughly located on a sketch of a brain. List 4 functional attributes that differ between these two extrastriate streams.

- C. You considered one pair of processing pathways in part A above, and a second pair of processing pathways in part B. How is the pair of pathways in part A related to the pair of pathways in B? In 1-2 paragraphs, describe how the processing pathways from A feed into, and are functionally related to, the processing pathways from B.

### **3. Phototransduction (1 point total)**

**Write the following events in the correct sequence as they occur during phototransduction. Begin with step (3).**

- (1) Increased cGMP concentration
- (2) cGMP is hydrolyzed into 5'GMP by cGMP phosphodiesterase
- (3) Light hits the eye
- (4) Na<sup>+</sup> and Ca<sup>2+</sup> influx
- (5) Cell is hyperpolarized
- (6) cGMP-gated channels open
- (7) Guanylate cyclase synthesizes cGMP from GTP
- (8) Rhodopsin absorbs light
- (9) Lowered Ca<sup>2+</sup>
- (10) cGMP-gated channels close in plasma membrane of outer segment

#### **4. Human Lesions (7.5 points)**

A patient suffered a rare disease that completely and selectively lesioned all cortex in his entire right cerebral hemisphere. All subcortical structures are spared, as is the cerebellum, the entire left hemisphere, and all white matter.

A. In about one paragraph for each question, describe the resulting impairments in each of the domains of functioning listed below. If there is no impairment, explain why not. If there is minimal or unclear impairment, explain. In each case, briefly describe where the relevant information is normally processed, and how it is conveyed there (the main white matter routes). (2 points total)

1. Sensation of discriminative touch on the body and face. Describe if this is impaired in any way, where on the body if so, and identify the specific region within the lesioned brain region in the patient that accounts for the impairment.
2. Vision. Describe if there is any aspect of vision that is impaired; be as specific as possible. Again, identify the specific region within the lesioned area that accounts for the visual impairment (if any) and explain how they lesion produced the impairment.
3. Ability to localize sounds in space. As with the other questions, specifically describe any impairment, which region in the lesioned area accounts for it, and how.
4. Pain sensation on the body and face. As with the other questions, specifically describe any impairment, which region in the lesioned area accounts for it and how.

B. A novel approach to help paralyzed patients, one under considerable recent research development, involves implanting electrodes into the brain in order to “read out” brain activity corresponding to the intention to move a part of the body. This can then be connected to a robotic prosthesis, so that certain patients who are paralyzed can move a prosthetic arm or leg just by thinking about it. Do you believe this approach could be developed to work in the patient described in A? Why or why not? (0.5 point)

C. Now suppose you have a patient where, rather than knowing the location of the lesion, you only know what the impairment is (the converse of A above). For each of the 3 deficits below, describe the MOST SPECIFIC SINGLE lesion anywhere in the brain (including subcortical structures or white matter) that would produce a complete deficit for the listed function, without introducing any other deficits or introducing the smallest number of additional deficits (e.g., complete loss of discriminative touch on the body and face without loss of any other sensory submodality). If it is impossible not to introduce other deficits, then state which other deficits would result and why. You may either describe the lesion location in words and/or draw a picture of where in the brain it would be. It is recommended that you describe the lesion in words AND also draw it, since partial credit may be given. (4 points total)

1. Partial loss of night vision and ability to detect moving stimuli in the left visual hemifield
2. Difficulty localizing low frequency, but not high frequency, sounds in space
3. Difficulty recognizing visually presented objects and faces, but intact ability to discriminate amongst them
4. Difficulty in planning into the future, despite entirely normal basic sensory and motor function

D. You have a patient who is hemiplegic (paralyzed) on the entire left side of the body but not the face, and can still move his trunk somewhat. He has a single, focal lesion to white matter somewhere. Draw and name the white matter tracts responsible specifically for the paralysis, as well as for his partly spared trunk movement. (0.5 point)

E. You test the reflexes of the patient described in D. Describe what you would find regarding the patellar tendon (knee-jerk) reflex, and why. (0.5 point)

## **5. Psychiatric diseases (7.5 points)**

Winnie the Pooh and his friends are enjoying a picnic in the Thousand Acre Woods when they fall into a deep discussion about their individual purposes in life. During this exchange, Eeyore remains quiet, until he points out, in his usual sad voice, that after his death, no one will even remember that he existed, not that it matters. At this point, he lumbers off to be alone.

Christopher Robin is worried about Eeyore. He confides in Pooh that he has been informed that Eeyore has been seeking help with major depression.

**A. (1 point)** What symptoms would Eeyore have to exhibit for a professional psychiatrist to diagnose a case of major depression? Name four of these symptoms.

**B. (1point total)** Christopher Robin knows that Eeyore is receiving the type of antidepressant medication that is most often prescribed for patients with major depression.

- i. What does this type of medication do, acutely, at the molecular level (0.5)?
- ii. How long is typically required for this medication to produce relief of symptoms (0.5)?

**C. (1 point)** Tigger, on the other hand, is quite bouncy. He may act manic at times. If he also shows signs of depression, would a psychiatrist prescribe the same medication as for Eeyore? Why or why not (2 sentences)?

In 2001, the American Journal of Psychiatry published a paper entitled: “Emily Dickinson Revisited: A Study of Periodicity in Her Work.”

<http://ajp.psychiatryonline.org/cgi/content/full/158/5/686>

This paper examines Dickinson’s writings from 1858-1865, her most prolific years.

The paper states, “These data, supported by excerpts from letters to friends during this period of Dickinson’s life, demonstrate seasonal changes in mood during the first four years of major productivity, followed by a sustained elevation of creative energy, mood, and cognition during the second. They suggest, as supported by family history, a bipolar pattern previously described in creative artists.”

**D. (1 total)**

**Name two symptoms you might seek if *you* were examining Emily Dickinson’s life for evidence of bipolar disorder.**

**Why would your research be incomplete if you merely examine her written work?  
(1-2 sentences)**

**E. (1 point total) True or False?**

**i. (0.25)** Emily Dickinson wrote over 1800 poems in her lifetime, most of them during a 10-year period. **Prolific work during a brief period is common in people with bipolar disorder.**

**ii. (0.25)** Emily Dickinson became a virtual shut-in after the Civil War and became very agoraphobic. **This behavior is common in people with bipolar disorder.**

**iii. (0.25)** Martha Dickinson Bianchi, Emily Dickinson’s niece, helped to edit and publish her poems after Dickinson’s death. **If the suggested diagnosis about Emily is true, then Martha is more likely than the general population to have had bipolar disorder.**

**iv.(0.25)** Emily Dickinson began losing her eyesight at age 34, which may have dramatically impacted her work. **This is a common symptom in adults with bipolar disorder.**

**F. (0.5 point)**

**If Emily Dickinson were living today, name two drug treatments that might be offered to her.**

**G. (1 point total)**

**i. (0.5) Many highly creative people with bipolar disorder reject drug therapies. Why?**

**ii. (0.5) What is the most significant risk for these people when they are not medicated?**

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**H. (1 point total) Schizophrenia**

**i. Name two symptoms that are present in schizophrenia but not in major depression or bipolar disease (0.5).**

**ii Name one drug (common name, not trademark, not drug class) that is used for treatment of schizophrenia therapy but not for major depressive disorder. Name its general class of target (0.5).**