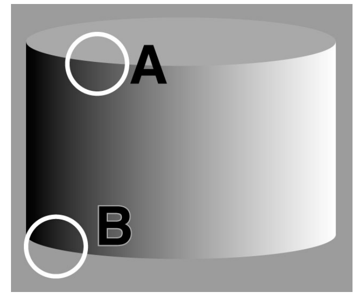
PSY 568/768 – Systems Neuroscience *Name*___________________________________

Second midterm exam – 8 equally-weighted questions (6-8 min/question)



1. This question concerns single neurons in primate visual area ***V1***.

(a) *First*, describe ***receptive field response properties (cell type)*** of **one** type of V1 neuron that would give ***different responses*** if its ***excitatory receptive field*** was placed at position **A** versus **B.** *Then* describe **second** type of V1 neuron that would give the ***same responses*** at **A** and **B** (several correct answers possible for both).

(b) Assume a V1 cell is ***orientation*** selective. Diagram a series of ***stimuli*** in the circles (each representing ***one stimulus*** in the receptive field of ***same neuron***) sufficient to estimate the neuron's ***orientation preference***.

(c) Some neurons in V1 are selective for the ***wavelength*** of a stimulus. Higher level visual areas use this information to compute the ***perceived color***. Describe a situation where the ***wavelength*** of light reflected from a small patch in a scene ***differs*** from the ***perceived color*** of that patch.

2. Macaque visual area V1 contains a ***map*** of ***visual space***. It ***also*** represents inputs from the ***left and right eyes, contour orientation, brightness, and movement direction*** in embedded submaps, some in different layers.

(a) Illustrate what a ***top view*** (that is, looking ***straight down*** onto the ***cortical surface***) of a portion of ***just layer 2/3*** would look like in the rectangle to the right by ***shading in the blobs*** and leaving the ***interblobs*** unshaded. Assume this cortex patch (a few mm across) contains 5-10 blobs.

(b) Now redraw the blobs as open circles and indicate how ***different orientations*** are arranged in the same patch of cortex ***layer 2 and 3*** by drawing ***short line segments*** to indicate ***preferred orientation*** only at places where neurons are orientation selective.

(c) Finally, illustrate the ***pattern of activity (***using ***shading*** to indicate ***increased activity***) that a ***black line*** would cause in layers 2/3. Assume the ***black line*** is presented on a ***white background*** and that the retinotopic map in this patch of cortex 'sees' ***both*** line and background. Illustrate activity in ***blobs*** (circles) as well as ***interblobs*** (between).

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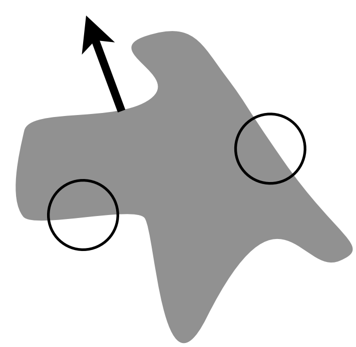
3. We discussed the Moran and Desimone experiment on the effects of ***visual attention*** in primate ***V4 neuron***s.

(a) How did the experimenters define an "attended stimulus" *versus* an "unattended stimulus"?

(b) Subsequent research found that the presence of multiple objects in the receptive field of a neuron can result in ***stimulus competition***. How does ***attention*** (as defined above) interact with ***stimulus competition***?

(c) The Moran and Desimone experiment envisioned a ***spatial*** 'spotlight' of attention, but did not explicitly test whether the 'spotlight' was in fact ***spatial*** -- the animal might have been attending ***instead*** to ***orientation***! ***Propose*** a new experiment to determine if V4 neurons show ***attention to orientation***. Describe ***stimuli***, animal's ***task***, and ***responses of a neuron*** showing attention to orientation.

4. We presented the ***aperture problem*** for ***pattern translation*** in class.

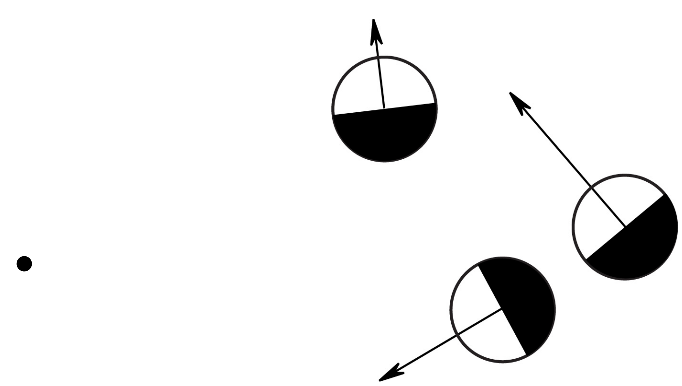


(a) The gray object at the right is moving in the direction shown by the ***thick arrow***. Draw the ***local direction*** that would be detected by two ***V1, layer 4B neurons*** with receptive field locations indicated by the ***two circles***? Draw ***length*** and ***angle*** of each of the two ***local motion directions*** as accurately as possible!

(b) Illustrate two different ***pattern motions*** using ***thick arrows***, then for each pattern motion, indicate the corresponding family of ***local motions*** using ***thin arrows*** that are ***consistent*** with each pattern motion.

Family 1 **Family 2**

(c) Three apertures view different parts of the ***same*** moving (translating) object. The ***local directions*** detected inside each aperture are shown with a ***thin arrows***. ***Accurately*** indicate ***direction*** the object is moving with a ***thick arrow*** (correct angle and length) rooted at the ***black point*** and ***diagram*** how answer was obtained.



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5. We described different types of ***somatosensory receptors***, and characteristic features of ***somatosensory maps***.

(a) If you picked up an object that was ***heavier*** than you were expecting, would you expect a response from ***<u>type Ia muscle spindles</u>?*** Explain your answer in one sentence.

(b) Describe where ***<u>type Ib receptors</u>*** are ***located***, and ***what they detect***.

(c) One end of a ***<u>somatosensory ganglion cell</u>*** forms a ***<u>receptor</u>*** while the other end makes ***<u>synapses</u>***. List at least ***<u>two different locations</u>*** where these ganglion cell synapses are made.

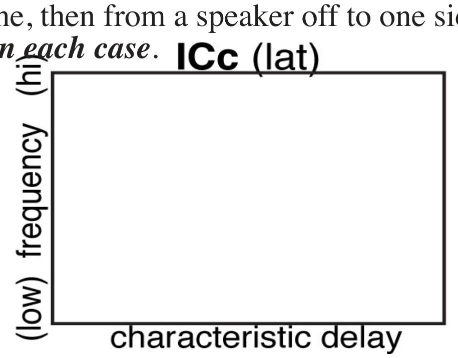
(d) In class, we heard that ***somatosensory*** cortical areas have "*discontinuities*" of a kind ***not*** found in ***visual*** areas. Briefly describe how those somatosensory-specific discontinuities can be ***<u>experimentally detected</u>***.

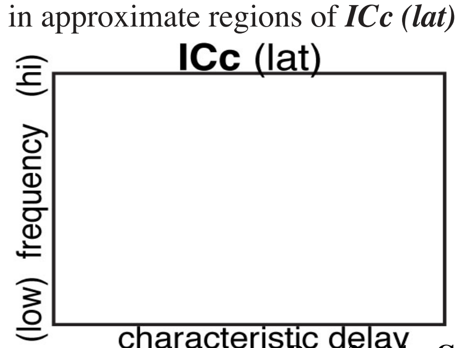
6. Auditory hair cells synapse on cochlear ganglion cells, which project via branching axons to the ipsilateral ***nucleus magnocellularis*** (NM) and ***nucleus angularis*** (NA) in the owl. ***Nucleus magnocellularis*** then projects to both the ipsilateral and contralateral ***nucleus laminaris*** (NL).

(a) Neurons in ***NM*** and ***NA*** have different response properties. What ***<u>neuroanatomical features</u>*** explain this?

(b) A soft click sound is made. Assume the ***only responses*** from the 1600 Hz parts of the left and right ***NM*** are ***<u>one spike</u>*** from the left NM and ***<u>two spikes</u>*** from the right NM. ***What is the maximum number*** of spikes you would expect to see across ***all*** the 1600 Hz neurons in ***<u>one NL</u>***? Briefly explain in words ***or*** with a diagram (assume ***NL*** background firing is zero and that there is only one NL spike per coincidence).

(c) The *tonotopic* ***central nucleus of the inferior colliculus, lateral part***, ICc (lat), receives input from nucleus laminaris (NL). Assume a sound containing ***<u>only 3 different frequencies</u>*** was first played from a speaker near the midline, then from a speaker off to one side. Shade in approximate regions of ***ICc (lat)*** that would respond ***in each case***.





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7. Neurons in ***MSTd***, which receives input from ***MT***, are selective for several different kinds of ***complex motions***.

(a) Compare the ***size*** of the ***excitatory receptive fields*** of neurons in ***V1 layer 4B***, ***area MT***, and ***area MSTd***.

(b) ***Describe*** (or ***diagram***) examples of two ***different*** complex motions preferred by two different MSTd neurons in the space to the right.

(c) ***Describe*** *(or* **diagram***)* how you would ***test*** if an ***MSTd response*** to a complex motion was ***position-invariant.***

(d) ***Describe*** **in words** the ***evidence*** that ***MT*** is ***not*** selective for ***complex motions***.

8. Echolocating bats analyzing echoes from high frequency calls reflected off of objects in their environment face ***computational problems*** similar to those faced by humans recognizing vowels and consonants in speech.

(a) ***If*** a ***CF_3 echo*** (echo from outgoing third harmonic) came back at 93 kHz after the bat emitted a ***CF_1*** (first harmonic of outgoing) at 32 kHz, does this mean that the target is moving ***toward*** or ***away*** from the bat? How did you tell?

(b) How does the bat detect the ***distance*** of a target?

(c) Different human ***vowel sounds*** are distinguished by their formant frequencies. What is a ***vowel formant***?

(d) Bats need to determine Doppler shift to detect target velocity and adjust their outgoing voice pitch to get echos in their 'acoustic fovea'**,** while humans need to determine which vowel is spoken independent of vocal tract size. What is the common ***signal processing problem*** that bats and humans must solve to do this?