

This is homework 1 for “Understanding Vision 1 (lecture), Summer 2024”, handed out April 29th, due May 15th.

Please answer the following multiple choice questions. **These choices are marked as A, B, C, etc. To pick a choice, e.g., choice A, please draw a circle around this letter, e.g., A.** For each question, pick one or more choices that you think are correct.

1. Along the visual pathway from retina, to LGN, V1, V2, etc to higher visual cortical areas, this is what happens.
A. neurons become more sensitive to spatial position and size of visual inputs
☒ B. The receptive field of the neurons become larger.
2. What is the first stage along the visual pathway?
☒ A. retina
B. the primary visual cortex
3. Typically, a neuron sends signals to other neurons via its
☒ A. axons
B. dendrites
4. what is a center-surround receptive field?
☒ A. this receptive field has two parts, center and surround.
B. the neuron having such a receptive field is most excited by visual inputs when the center and surround are both bright, or when the center and surround are both dark
☒ C. this receptive field is sensitive to luminance contrast between the center and surround regions.
5. a neuron is likely excited by a bright spot in a blank field when
☒ A. this neuron has an on-center-off-surround receptive field, and the bright spot is in the center region of the receptive field.
B. this neuron has an on-center-off-surround receptive field, and the bright spot is in the surround region of the receptive field.
☒ C. this neuron has an off-center-on-surround receptive field, and the bright spot is in the surround region of the receptive field.
D. this neuron has an off-center-on-surround receptive field, and the bright spot is in the center region of the receptive field.
6. For a luminance grating, the frequency of the grating
A. increases when the wavelength of the grating increases
☒ B. decreases when the wavelength of the grating increases
7. If the receptive field of the neuron is an on-center-off-surround receptive field, then this neuron’s response to a grating is highest when
☒ A. a peak in the grating is centered at the center of this receptive field
B. a trough of the grating is centered at the center of this receptive field.
8. Each retinal ganglion cell, with a center-surround receptive field, can be best excited by a grating with an optimal spatial frequency. When this receptive field becomes smaller,
☒ A. the spatial frequency of this optimal grating should become larger
B. the spatial frequency of this optimal grating should become smaller

9. To build a receptive field by a weighted summation of Fourier waves, the wave with the largest weight (by magnitude) is the one
 - ☒ A. whose frequency is where the contrast sensitivity function peaks
 - B. with the lowest frequency
 - C. with the highest frequency
 - ☐ D. whose wavelength is roughly the same as the size of the receptive field
10. Fourier transform of a receptive field is to represent the shape of this receptive field by
 - ☒ A. a weighted summation of sine and cosine waves of various spatial frequencies
 - B. the average of many sine and cosine waves of various spatial frequencies
11. If the shape of the receptive field is symmetric, such that its left half is the mirror image of its right half, and if this receptive field is centered at spatial location $x=0$, the middle of the display screen, then
 - ☒ A. the receptive field is a weighted sum of cosine waves only.
 - B. the receptive field is a weighted sum of sine waves only.
 - C. the receptive field is a weighted sum of cosine waves and sine waves
12. When the width of a Gaussian function becomes larger, the width of its Fourier transform in frequency space becomes
 - ☒ A. smaller
 - B. larger
13. A neuron has a spatiotemporal filter to transform visual inputs to its response or output. This spatiotemporal filter does the following transform
 - A. It takes a spatial input and turns it into a temporal neural response
 - ☒ B. it takes a spatial input pattern, which can vary in time, and turns this into a temporal response of the neuron
14. When a spatial input pattern onset at time $t = 0$, in what time window is the response of the neuron called the transient response?
 - ☒ A. very soon after time $t=0$
 - B. long after time $t=0$
15. when a visual spatial pattern onset at time $t = 0$ and stays on, what is the sustained response of a neuron to this input?
 - A. immediately before $t = 0$
 - ☒ B. very long after $t = 0$, much longer than the time scale in time neural responses change.
16. For a neuron, its impulse response function $K(x, t)$ is a function of space x and time t , such that given visual input $S(x, t)$, which is also a function of x and t , the output of this neuron O at time t is $O(t) = \sum_{t'} K(x, t - t') S(x, t')$. Hence, $K(x, t)$ is non-zero for a finite time window, i.e., for a finite range of t values, where $t = t_2 - t_1$ is the difference between the neural response time t_2 and the input time t_1 . Which one of the follow statements are correct?
 - ☒ A. when $t < 0$, $K(x, t) = 0$
 - B. when $t > 0$, $K(x, t) = 0$.
 - ☒ C. $K(x, t)$ is non-zero around $t = 100$ ms.

17. If an input visual pattern onset at time $t = 0$ and stays on forever, the sustained response of a neuron will be substantially non-zero when the impulse response function $K(x, t)$ has the following property
 - ☒ A. when $K(x, t)$ has only positive (excitatory) values and no negative (inhibitory) values for all x and t .
 - B. when the integration of $K(x, t)$ over all time t is roughly zero, i.e., when $K(x, t)$ has roughly as much excitatory as inhibitory components across time t .
18. how many cone types does human retina have normally?
 - A. two
 - ☒ B. three.
19. the sensitivity of the green cone to input lights peaks at an intermediate wavelength of visible light. This peak wavelength is closer to the peak wavelength of which cone type?
 - ☒ A. the red cone
 - B. the blue cone
20. in primate retina, are the parvo- or magno- cellular cells more numerous?
 - ☒ A. Parvocellular
 - B. Magnocellular
21. are the parvo- or the magno-cellular cells more sensitive to input luminance?
 - ☒ A. magnocellular
 - B. parvocellular
22. the distance between neighbor cones
 - A. decreases with increasing eccentricity from the fovea
 - ☒ B. increases with increasing eccentricity from the fovea
23. In dim light, the cones are not functioning, the rods helps seeing. Where is visual acuity highest?
 - A. at fovea
 - ☒ B. about 10-20 degrees from fovea
24. Visual inputs from the left half of the visual field are processed
 - ☒ A. in the right half of the brain
 - B. in the left half of the brain
25. the visual field within 2.5 degrees of eccentricity from fovea is processed by
 - ☒ A. about 20 to 30 percent of V1's surface area
 - B. about 10 percent of V1's surface area
 - C. less than 5 percent of V1's surface area
26. A V1 neuron is typically tuned to orientation, and to spatial frequency. The range of the frequency of gratings that can substantially excite this neuron is
 - ☒ A. inversely proportional to the length or width of the receptive field
 - B. increases with the size of the receptive field
27. If we model a neural receptive field by a gabor filter, which of the following statements best describes the parameters of the model?
 - ☒ A. width and length of the Gaussian envelop, the spatial frequency of the sinusoidal wave, and phase in this sinusoidal wave, and the orientations of the axes for the gabor filter.
 - B. Spatial extent, frequency, and orientation of the sinusoidal wave.

28. Typically, V1 neurons tuned to higher spatial frequencies
- ☒ A. have a smaller receptive field
 - B. have a larger receptive field
29. In octave, what is the typical width of frequency tuning curve for a V1 neuron?
- A. one octave
 - ☒ B. 1.5 octave
30. color selective neurons in V1 tend to be
- ☒ A. tuned to lower spatial frequencies than neurons not selective to color
 - B. tend to have smaller receptive fields
 - C. are only tuned to red versus green colors
31. V1 neurons not tuned to orientation tend to
- ☒ A. have larger receptive fields
 - B. have smaller receptive fields
 - ☒ C. be tuned to color
 - ☒ D. they constitute only a minority of V1 neurons
32. V1 neurons tuned to motion direction
- A. are the only neurons that have a temporal dimension for their receptive field properties
 - ☒ B. have a space-time non-separable spatiotemporal filter
33. Using the quadrature model to build a motion direction tuned spatiotemporal filter
- A. one must add with equal weights two separate motion direction un-tuned filters. These two separate sub-filters are related to each other, such that, in both their spatial filter and temporal filter dimension, the two sub-filters differ from each other by a 90 degrees phase angle
 - ☒ B. as in the choice above, but the two weights do not have to be equal as long as they are both non-zero
 - ☒ C. as in the choice above, one can also build a motion direction tuned neuron using two weights that are equal in magnitude but opposite in sign
 - ☒ D. in (B), the more equal the two weights are in magnitude (but not necessarily in sign) to each other, the more sensitive is the receptive field to motion direction
34. binocular disparity of an object is
- ☒ A. the difference between this object's image location in the left eye and its image location in the right eye
 - ☒ B. is zero when the gazes of both eyes are directed to this object
 - ☒ C. this disparity can sometimes also be zero when the gaze is not directed to this object
 - D. this disparity is never zero when the gaze is not directed to this object
35. A binocular neuron is a neuron
- ☒ A. that is equally sensitive to inputs from the two eyes
 - B. Its receptive field for the left eye input must be equal to its receptive field for the right eye input
36. Monocular neurons are more sensitive to inputs from one eye than the other eye
- ☒ A. Only V1 has a substantial percentage of its neurons monocular
 - B. Ocular dominance columns are absent in visual cortical areas beyond V1, not because there are no monocular neurons there, but because these neurons are not clustered into columns.

37. when an object is closer to the viewer than where the viewer is fixating in 3D space, its binocular disparity (defined as $x_l - x_r$, where x_l and x_r are this object's position in the image for the left and right eyes)
- ☒ A. tends to be positive
 - B. tends to be negative
38. simple cells are those
- A. whose response is a linear function of the visual input signal
 - ☒ B. Their responses can be modeled by a static nonlinearity of the outcome from a linear filter. The neural response can be approximated by the outcome from a linear filtering of the visual input only in a limited region, the response has a threshold and a saturation.
39. complex cells are those neurons,
- ☒ A. their responses cannot be described by a static nonlinear function of the outcome from a linear filtering of the visual inputs
 - B. their response can be modeled by a more complex static linear function of the outcome from a linear filtering of the visual inputs
 - C. Their spatiotemporal linear filters for the visual inputs are very complex, even though the neural responses can be described as the outcome from a static nonlinear transform from the outcomes of the linear filters.
40. Please tick all correct statements below about the energy model of complex cells
- ☒ A. The energy model models a complex cell's response as the summation of the squares of the outcomes from two linear simple cells whose receptive fields form a quadrature pair
 - B. The outcome of the energy model is more sensitive to the spatial location of the visual inputs than the outcome of a simple cell.
 - ☒ C. The energy model's response to a grating is not sensitive to the phase of this grating.
41. Which of the following statements are correct?
- ☒ A. One may build a more linear, abstract, simple cell by adding the responses from two component cells, which are nonlinear simple cells in V1. Each of the component cell's response can be modelled by a static non-linear function of the outcome from a linear filter K, and these two component simple cells are related to each other so that their filters K are identical to each other except for a sign, so that one cell's on region of the receptive field is the off region of the other cell's receptive field.
 - B. In (A), the outcome of this abstract simple cell is a perfect linear function of visual input signals
 - ☒ C. In (A), the outcome of this abstract simple cell is only an approximately linear function of visual input signals. For example, it can still have response saturation, since each component cell has a response saturation.
42. In the motion energy model, the complex cell's response is response = squares of L1 + squares of L2, L1 and L2 are from responses of motion direction selective linear filters,
- ☒ A. L1 and L2 should have the same preferred motion directions
 - B. The preferred directions for L1 and L2 do not have to be the same
 - ☒ C. L1 and L2 should be related to each other, so that their spatiotemporal filters form a quadrature pair.
 - ☒ D. in response to a moving grating, while L1 and L2 can oscillate in time, the response of the motion energy model will not oscillate in time substantially.
43. For a disparity tuned complex cell that can be described by a disparity energy model using simple cell components modelled as gabor filters, its response is tuned to input disparity D,
- ☒ A. this complex cell's response is also sensitive to the location of the visual input, and this sensitivity is approximated by the shape of the Gaussian envelop of the gabor filters.

- B. this complex cell's response is also sensitive to the location of the visual input, and this sensitivity is approximated by the shape on and off subregions of the gabor filters
- C. this complex cell's response is not sensitive to the location of the visual input so that visual inputs can even be outside the gaussian envelop of the gaussians.
44. A V1 neuron's response can be influenced from contextual inputs from outside its receptive field. One idea is that this influence is mediated by intracortical connections in V1. If so, in terms of the distance in millimeters on V1's surface, how far is the contextual input mainly coming from (in primates) ?
- ☒ A. within a few millimeters
- B. from as larger as the whole V1 cortical surface
45. contextual influences are dominantly
- ☒ A. suppression
- B. excitation
46. For a V1 neuron tuned to horizontal orientation, if it is responding vigorously to an horizontal bar inside its receptive field when there are no contextual bars outside its receptive field,
- ☒ A. its response will be suppressed more by horizontal bars, rather than vertical bars, surrounding its receptive field
- B. its response will be suppressed more by vertical bars, rather than horizontal bars, surrounding its receptive field
- C. its response will be suppressed more by randomly oriented bars, rather than horizontal bars, surrounding its receptive field
47. It is still controversial as to what are likely causes for the contextual influences. Before it is completely settled by data, please name the possible causes as
- ☒ A. from other V1 neurons via intra-cortical mechanisms and from influences from higher visual areas
- B. from intra-cortical mechanisms within V1, but one must consider all kinds of intra-cortical mechanisms
- C. from various brain areas outside V1, and one must determine which brain areas are responsible
48. the size of the visual receptive fields change along the visual hierarchy, so that in primates
- ☒ A. the sizes are small in V1, and on average they become larger and larger downstream
- ☒ B. the sizes of IT neurons can be as large as 50 degrees in visual angle
- C. the sizes of the receptive fields are similar across visual cortical areas, except for IT neurons which have really big receptive fields for object recognition
49. A popular idea divides the visual areas into those in ventral and dorsal streams, so that
- ☒ A. those in the ventral stream are more concerned with object recognition, or about what an object is, and those in the dorsal stream are more concerns with where objects are.
- B. ventral and dorsal streams are anatomical locations of the visual cortical areas, but there is no implications on the functions of the cortical areas in those streams
50. Which visual cortical area cover the largest extent of the visual field in its neural responsiveness to visual inputs?
- ☒ A. V1, which covers more than 80 degrees in visual angle from the straight-head direction to left and to right laterally.
- B. IT, which has very larger receptive fields for its neurons.

51. The sizes of the receptive fields of V2 neurons are
- A. about the same those of V1 neurons
 - ☒ B. slightly larger than those of V1 neurons
52. Please pick all correct answers below
- ☒ A. V2 neurons are more likely sensitive to the orientation of illusory contours than V1 neurons
 - ☒ B. V2 neurons are more likely sensitive to the ownership of a luminance border or bar than V1 neurons
53. MT is considered a dorsal stream area or ventral stream area?
- A. ventral
 - ☒ B. dorsal
54. compare to the sizes of neural receptive fields in V1 neurons, the sizes of the MT/V5 neurons are
- A. about 5 times larger in diameter
 - ☒ B. about 10 times larger in diameter
55. MT is best known for its processing of
- ☒ A. visual motion
 - B. visual color
 - C. curvature of a contour
56. Compared to the sizes of neural receptive fields in V1, the sizes of neural receptive fields of V4 neurons are
- A. about 10 times larger in diameters
 - ☒ B. about 4-7 times larger in diameters
57. V4 lesions cause
- ☒ A. severe impairment of shape recognition
 - ☒ B. cause animals unable to respond to non-salient visual inputs.
58. sizes of neural receptive fields for IT neurons are
- ☒ A. about 20-50 degrees in visual angle
 - ☒ B. typically larger than those of V4 neurons
 - C. as larger as the whole visual field
59. What are the categories of visual inputs that some IT patches are known to specialized for according to literature?
- ☒ A. faces,
 - ☒ B. scenes
 - ☒ C. body parts
60. What is the name of the retinal problem to cause central versus peripheral vision loss?
- ☒ A. macular degeneration versus glaucoma
 - B. glaucoma versus macular deneneration
61. After V1 lesion by surgery, can monkeys saccade to a visually very salient flashed spot immediately after recovery from surgery?
- A. yes, they can, because there is blindsight after V1 lesion
 - ☒ B. no they cannot, until after several weeks, on average 2 months, for the brain to re-organize.

62. Lesion in which stream cause a patient unable to recognize the orientation of a slot but can post letters to this slot by motor actions?
- A. dorsal stream
 - ☒ B. ventral stream
63. strokes in which brain regions are linked with hemineglect?
- ☒ A. right parietal lobe
 - B. superior colliculus
64. Neural response latency becomes longer as signal progress along the visual pathway. What is the latency in V1 versus in IT?
- ☒ A. 40 ms versus 100 ms
 - B. 20 ms versus 150 ms.
 - C. 70 ms versus 140 ms
65. On average how many times do we move our eyes by saccades each minute?
- A. 10 times a minute
 - B. 100 times a minute
 - ☒ C. 180 times a minute
66. What are the two major types of eye movements?
- ☒ A. saccades and smooth pursuits
 - B. saccades and eye jitters
67. Is it possible to fixate your gaze to one location while paying attention to another location?
- A. no
 - ☒ B. yes
68. Is it possible to shift your gaze to your left while paying attention to your right?
- ☒ A. no
 - B. yes
69. How do we assess behaviorally whether somebody is paying attention or not?
- ☒ A. by assessing whether his/her performance in a sufficiently difficult visual discriminate task is accurate or fast enough.
 - B. by asking this person to report whether he or she is paying attention
70. Superior colliculus, V1, frontal eye field, and parietal cortex can all send signals that lead to eye movements, which of the following is a brain area that signal have to go to in order to enable eye movement?
- ☒ A. brain stem
 - B. frontal brain command centers
71. Among V1, frontal eye fields, and parietal areas, which one can by pass the superior colliculus to send commands directly to the brain stem for eye movements?
- ☒ A. frontal eye field
 - B. V1
 - C. parietal cortex

72. for visually guided saccades (i.e., saccades to visual inputs), rather than memory guided saccades, is V1 necessary in normal monkeys?
- ☒ A. yes, V1 processes all visual inputs, even those sent downstream to parietal cortex and frontal eye field for driving saccades,
 - B. no, since there is direct inputs from retina to superior colliculus bypassing V1. Monkey with V1 lesions can also make saccades to visual inputs.
73. What is receptive field remapping?
- ☒ A. neurons shift their receptive fields just before a saccade, so that they respond to visual inputs that are at a location which will be brought into the receptive fields by the impending saccade.
 - B. neurons shift the locations of their receptive fields as soon as a saccade is completed.
 - C. neurons shift the locations of their receptive fields soon after the completion of a saccade.
74. receptive field remapping is associated with neurons in which brain area?
- ☒ A. frontal eye field, parietal cortex, and superior colliculus (deeper layers)
 - B. early visual areas like V1.
75. Which of the following suggests that motor commands for saccades can be equivalent to paying attention to the saccadic destination?
- ☒ A. Stimulating a neuron in superior colliculus can elicit a saccade to the movement field of this neuron. Flashing a light in that movement field to attract attention has a similar effect as stimulating that neuron to affect the trajectory of a saccade
 - ☒ B. as above, but replacing the flashing light by voluntarily paying attention to the movement field works similarly.
76. visual discrimination performance is better at
- ☒ A. the receptive field location of more activated neurons in LIP
 - ☒ B. the movement field of the stimulated neuron in frontal eye field (FEF) or superior colliculus, even when such stimulation is sub-threshold so that no eye movements are evoked.
77. Which of the following statements is correct?
- A. Neural activities in V4, IT, MT are completely determined by the visual inputs, independent of the attentional states of the animal.
 - ☒ B. Neural activities in V4, IT, MT depend on the attentional states, even when the retinal inputs stay unchanged.
78. In some V4 and IT neurons, when there are two objects inside the receptive field, paying attention to one of the two objects causes
- A. the neuron to respond less
 - B. the neuron to respond more
 - ☒ C. the neuron to respond as if the non-attended object was absent
79. Which of the following are among the typical attentional effects observed for extrastriate visual cortical neurons, in response to visual inputs?
- ☒ A. neurons increase their sensitivity to visual inputs within their receptive fields by attention to these inputs
 - ☒ B. attention to visual inputs within the receptive field increases the effective input strengths of these inputs
 - C. attention to visual inputs within the receptive field decreases the effective input strengths of these inputs

- ☒ D. feature tuning curves of the neuron can be sharpened by visual attention to the inputs within the receptive field
 - ☒ E. feature tuning curves to visual inputs within the receptive field can be scaled up by attention to these inputs
80. The effects of top-down attention on neural responses in V1 are
- ☒ A. typically weaker than those on neural responses in visual cortical areas beyond V1
 - B. typically stronger than those on neural responses in visual cortical areas beyond V1
 - C. comparable in strength to those on neural responses in visual cortical areas beyond V1
81. What is a reason for a relative lack of data on the effect of exogenous attention on neural responses?
- ☒ A. Exogenous attentional shift is caused by external visual inputs, so it is difficult to distinguish between (1) changes of external visual inputs as the reasons for changes in the neural responses, and, (2) changes in exogenous attention as the reasons for changes in the neural responses.
 - B. the effects of exogenous attention are too weak to measure easily
82. What are the effects of visual tasks on contextual influences on V1 neural responses (as described by Li et al 2004)?
- ☒ A. The neuron's responses to visual inputs within its receptive field is affected more by the positions of the task relevant (than irrelevant) visual inputs outside the receptive field.
 - B. The neuron responds more strongly to the visual inputs within its receptive field when doing one task versus doing the other task
 - C. The neuron becomes more sensitive to task relevant contextual visual inputs outside the receptive field, than to the inputs within its receptive field.
83. In terms of the three stages in vision: encoding, selection, and decoding, each behavioral task is likely to involve all these three stages, each in a larger or smaller extent. After effects of visual adaptation (such as color adaptation) involve mostly which stage?
- ☒ A. encoding
 - B. selection
 - C. decoding
84. Following the last question, if we study the phenomenon of color constancy, which is the observation that an object, e.g., an apple, typically appear to have the same color (e.g., red), regardless of whether it is illuminated by a red light or green light, at least in typical natural environment. Which of the three stages, encoding, selection, and decoding, do you think is mainly involved in this constancy?
- A. encoding,
 - B. selection,
 - ☒ C. decoding