

Vision Science II – Monocular sensory aspects of vision

Exam 2 – Light adaptation, spatial & temporal vision, motion & depth perception

10/18/06

Maximum points = 51

1. At very low light levels the increment threshold in a light adaptation experiment is mainly determined by fluctuations in the light source rather than the visual system. In this case, the threshold increases in direct proportion to the ... (1)
 - a. neural noise.
 - b. background luminance.
 - c. square-root of background luminance.
 - d. visual acuity.

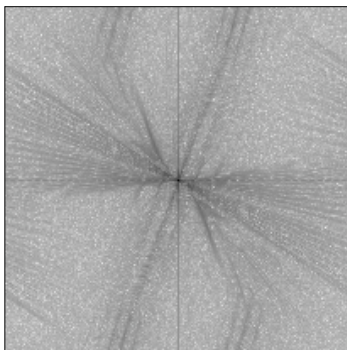
2. Over most of the scotopic and photopic ranges of vision, the increment threshold in a light adaptation experiment increases in direct proportion to the ... (1)
 - a. neural noise
 - b. background luminance
 - c. square-root of background luminance
 - d. visual acuity

3. How does the absolute sensitivity of the eye for detecting a luminance increment against a uniform background change with increasing light adaptation? (1)
 - a. It remains the same.
 - b. It increases.
 - c. It decreases.
 - d. None of the above.

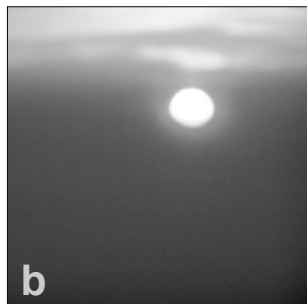
4. The Humphrey Visual Field Analyzer uses a single light bulb to illuminate both the background and spot. Because of this, fluctuations in the bulb's luminous output have little effect on visual field measurements, as long as Weber's law holds. Why? (3)
 - Fluctuations in the bulb will the cause luminance of both the spot and background to change by the same relative amount.
 - The spot will therefore always have the same contrast or luminance increment relative to the background.
 - If Weber's law holds, the increment threshold will be a constant fraction of the background, that is, the same contrast relative to the background.
 - So even if the bulb brightness changes, the contrast will be the same and the eye's ability to detect contrast will remain the same.

5. According to Ricco's Law, for spot diameters smaller than the critical diameter, the total number of quanta necessary for detection ... (1)
 - a. remains constant.
 - b. increases for smaller spot diameters.
 - c. decreases for smaller spot diameters.
 - d. is unrelated to spot diameter.

6. According to Bloch's Law, for durations within the critical duration, the intensity (quanta/time) necessary for detection ... (1)
- remains constant.
 - increases with increasing duration.
 - decreases with increasing duration.
 - is unrelated to duration.
7. The Stiles-Crawford effect is ... (1)
- caused by stray light inside the eye.
 - unrelated to optical and morphological properties of photoreceptors
 - caused by the nerve fiber layer and ganglion cells.
 - an indicator of photoreceptor orientation toward the center of the pupil.
8. Name three aspects of the photopic system that optimize quality of vision at the expense of sensitivity. (3)
- Small spatial summation areas
 - Short critical durations
 - Stiles-Crawford effect
 - 3 classes of photoreceptors for color vision
9. Name three aspects of the scotopic system that optimize sensitivity at the expense of quality of vision. (3)
- Large spatial summation areas
 - Long critical durations
 - No Stiles-Crawford effect
 - Single class of photoreceptors
10. The figure below shows a gray-scale plot of the spatial frequency spectrum of a picture. Which of the following pictures is it from? (2)

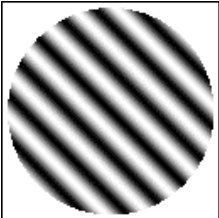
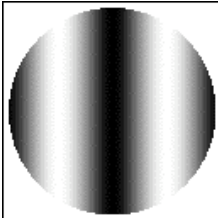
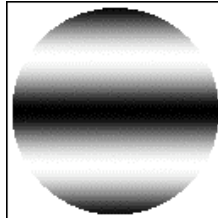
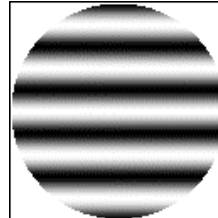
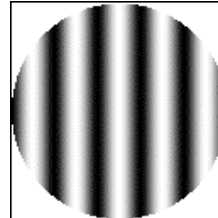


- Bowl of yummy tofu
- Beautiful sunset
- Commercial airliner
- Tall building

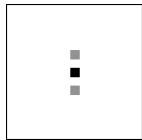
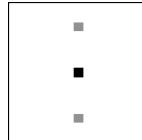
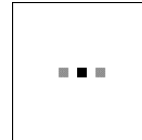
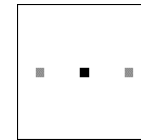
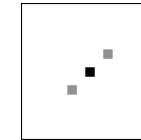
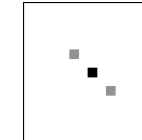
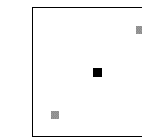


11. The interferometer is used to measure a patient's retinal visual acuity behind a cataract. From the doctor side of the instrument you see three small lights in the patient's pupil. The patient sees a sine wave grating, which is the inverse Fourier transform of the pattern that the doctor sees in the pupil. The figures below show five sine wave gratings (A-E), followed by seven magnified images of Fourier spectra (1-7). Match the grating with its spectrum by writing the spectrum's number in the box below each grating. (5)

Patient sees this.

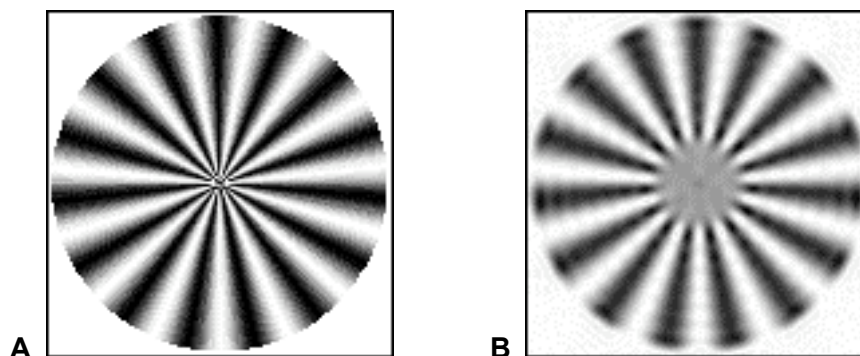
| | | | | |
|---|---|---|--|---|
| A | B | C | D | E |
|  |  |  |  |  |
| 7 | 3 | 1 | 2 | 4 |

Doctor sees this.

| | | | | | | |
|---|---|---|---|--|---|---|
|  |  |  |  |  |  |  |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

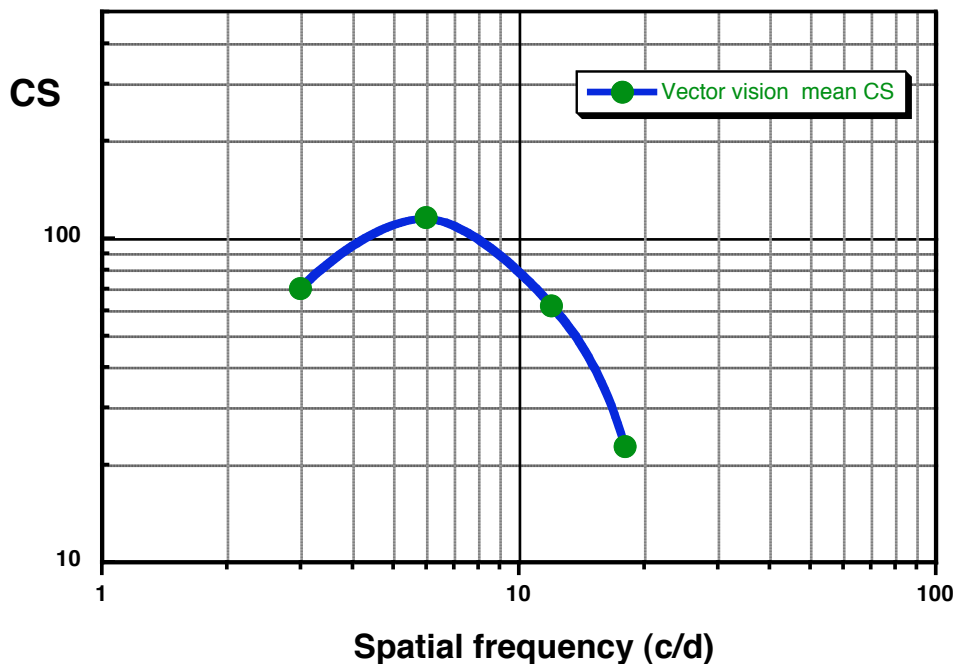
12. Sine wave gratings have certain properties that make them particularly well suited for studying vision. Which of the following is not a property of sine wave gratings? (1)
- They are fundamental building blocks of images.
 - The fit in nicely with the mathematical process known as Fourier transformation.
 - The image of a sine wave grating is a sine wave grating of the same frequency but lower contrast.
 - Optical blur reduces the spatial frequency but not the contrast.**

13. Refer to Figures A and B below. Figure B represents a spatial filtered version of A. What kind of spatial filter produced Figure B? (1)
- Low-pass filter**
 - High-pass filter
 - Band-pass filter
 - Vertical only high-pass filter



14. Explain why spatial filtering mainly changes only the central portion of the pattern rather than uniformly blurring the entire pattern. (2)

- The higher spatial frequencies are all at the center.
- The spatial filter has removed the highest spatial frequencies only, therefore only the center of the pattern is blurred.



15. The figure above shows the mean contrast sensitivity function (CSF) for the class as tested by the VectorVision CS-1000 chart. The four dots represent the spatial frequencies tested. List the Snellen visual acuities that correspond with each of those spatial frequencies. (2)

3 c/d = 20/200; 6 c/d = 20/100; 12 c/d = 20/50; 18 c/d = 20/33

16. What was the contrast for each stimulus represented by the four dots on the CSF? (2)

From left to right: 1.4%, 0.9%, 1.6%, 4.4%

17. Based on the CSF above, what is the lowest contrast that the person should be able to see for 20/75-sized letter?

1%

18. The VectorVision chart is designed to be viewed from a distance of 10 feet. At that distance, the person can barely see the stimuli represented dots on the graph. If the patient were free to view the chart at any distance, at which distance would the highest frequency stimulus (far right dot) be most easily seen? Base your answer on the CSF plotted in the figure above. (1)

3.33 feet

19. Assume the following: The patient's eyes have diffraction-limited optics, and his visual acuity is limited only by the Nyquist frequency of his foveal cone array. The foveal cones are packed together with no space between cones. One degree of visual angle corresponds with a distance of 300 μm on the retina. The patient has a visual acuity of 20/10. Based on this, calculate the diameter of one of his foveal cones. (2)

- For 20/10, the MAR = 0.5 arc minutes. This is the width of one cone in arc minutes.
- How many cones are in one degree (60 arc minutes)? $60/0.5 = 120$ cones per degree.
- That is, 120 cones per 300 μm . So one cone diameter = $300/120 = 2.5 \mu\text{m}$.

20. Colin Blakemore did a famous experiment in which subjects stared for several minutes at a 6 c/d square-wave grating before he measured their contrast sensitivity with sine-wave gratings. He found notches in the CSF at 6 and 18 c/d. What cause the decrease in contrast sensitivity at those spatial frequencies? (3)

- A 6 c/d square-wave grating is made up of sine-wave gratings with the following spatial frequencies: 6, 18, 30, 42, 54, 66 c/d and so on (odd multiples of 6).
- By staring at this pattern, the subject's visual system became adapted, that is it became desensitized to only those spatial frequencies.
- Therefore, they had reduced CS at those frequencies. The only frequencies that showed up on the test were 6 and 18, since the patient probably couldn't see the higher frequencies at all.

21. Under ideal conditions, Vernier acuity thresholds can be as good as ... (1)

- 2 to 10 arc seconds
- 2 to 10 arc minutes
- 2 to 10 degrees
- 2 to 10 radians

22. If a patient has cataracts, you will want to verify that his retina is capable of supporting good visual acuity before referring him for surgery. You can verify retinal acuity using an interferometer or potential acuity meter (PAM). If you don't have either of these instruments, you could accomplish the same thing by testing his Vernier acuity. The person would most likely benefit from cataract surgery if ... (1)

- both the Snellen acuity and Vernier acuity were normal.
- the Snellen acuity and Vernier acuity were both reduced.
- the Snellen acuity was normal but the Vernier acuity was reduced.
- the Snellen acuity as reduced but the Vernier acuity was normal.

23. Assume you are using an ETDRS high contrast chart to test visual acuity. A patient can read all of the 0.3 line and most of the 0.2 line, but misses two letters on the 0.2 line. What are his (A) logMAR, (B) MAR and (C) Snellen equivalent visual acuity, and (D) the decimal visual acuity. (4)

- Missed two letters on 0.2 means the logMAR acuity is 0.24.
- The MAR is then, $10^{0.24}$, which is equal to 1.74 arc minutes
- Multiply this by 20 for the Snellen denominator: $20 \times 1.74 = 35$. Snellen VA is 20/35.
- Decimal acuity = $20/35 = 0.57$

24. If a patient received a Snellen-equivalent score of 20/105 on the ETDRS chart, which line did he read to and how many letters did he miss on that line? (1)

- $MAR = 105/20 = 5.25$
- $\log MAR = 0.72$
- He read the 0.7 line but missed one letter on that line

25. The temporal modulation transfer function provides information about the visual system, including all of the following, except one. Which one? (1)

- a. The temporal frequency at which the eye can best see flicker.
- b. The length of the critical duration for temporal summation.
- c. The fastest flicker that a person can see.
- d. The lowest temporal contrast a person can see.

26. According to the Ferry-Porter law, the CFF ... (1)

- a. is directly proportional to stimulus luminance.
- b. is directly proportional to the log of the stimulus luminance.
- c. is inversely proportional to the log of the stimulus luminance.
- d. increases as the log of stimulus area.

27. Which of the following correctly describes the relationship between the size of a flashing light and the maximum rate of flicker than a person can normally see (Granit-Harper law)? (1)

- a. As a flashing light gets smaller, the flicker will be easier to see.
- b. The fastest flicker that a person can see remains constant for flashing lights of any size.
- c. As a flashing light gets larger, the flicker will be easier to see.
- d. As a light becomes dimmer at the same time it becomes smaller, the flicker becomes easier to see.

28. According to the Broca-Sulzer effect () ... (1)

- a. the longer a light (with fixed radiance) is left on, the brighter it appears to become.
- b. a flickering light appears dimmest if it is flashed at a rate of about 10 Hz.
- c. a light that is flashed on for about 75 msec will look slightly less bright than a steady light of the same radiance.
- d. a light that is flashed on for about 75 msec will look slightly brighter than a steady light of the same radiance.

29. As the optometrist (and vision expert) in Portales, New Mexico, the engineer at a local company asks for your advice in designing a flashing light for bicycle riders. He specifically would like to know how quickly the light should flicker in order for it to be most visible. Assuming that the radiance of the light will be constant, you should advise him that ... (1)

- a. any rate of flicker is OK, since a flickering light always looks brighter than a steady light.
- b. a steady light is best, since it will always appear brighter than a flickering light.
- c. it should be designed to flicker at about 10 Hz for maximum brightness enhancement.
- d. it should be designed to flicker at 75 Hz or greater, because above the CFF the light will appear to become brighter.

30. Briefly explain how size constancy explains the moon illusion. Write on the back if necessary. (3)

- The angular size of objects decrease as they get farther away, so an object that is far away should have a smaller retinal image size than if it were near.
- Visual cues create the impression that the moon on the horizon is farther away than when it is high in the sky.
- Since it appears to be farther away, yet it's retinal image size does not decrease, it has, in effect, increased in size relative to what the brain expects. Therefore it looks larger.