



## Contrast Sensitivity

by Sherry Van Liere, CPOA

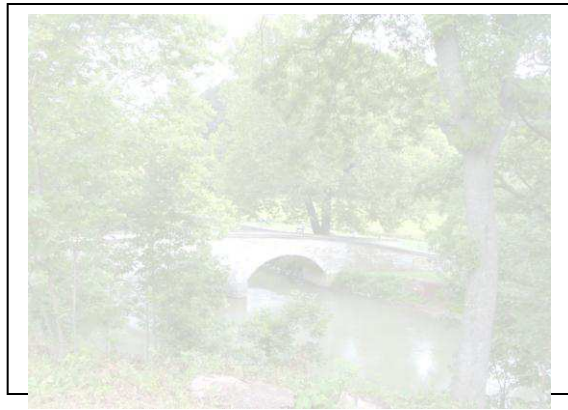
“It’s not what you look at that matters, it’s what you see.”

— [Henry David Thoreau](#)

Things in life aren’t always black and white. Yet, that’s how we measure our patients’ visual acuities – black symbols on a white background, the traditional Snellen Eye Chart. This chart measures how well a patient sees; if a patient reads the 20/20 line, we say acuities are normal.

But, what do you do when Mrs. Jones says, “I just don’t see things the right way,” even though her acuities with her glasses are 20/20. She may see 20/20, but she may have difficulty distinguishing an object from its background. Driving, especially at night, may be difficult; picking out a friend at the local mall may be difficult. She can’t tell you exactly what the problem is, only that she doesn’t see like she used to, and she’s not comfortable with her vision. Mrs. Jones may have a lower-than-normal contrast sensitivity.

Contrast sensitivity is the visual ability to distinguish an object from its background; it is not the same as visual acuity. The objects within our visual field are of varying size, color and brightness; some things are close, some are far; some things consist of a myriad of details while other things are almost monotone. When all of these images enter the pupil in the form of light waves, the cells in our retina must begin to make sense of them, and the images sent to the brain are interpreted as the world in front of us.



The picture on the right above shows how a person with reduced contrast sensitivity might view a scene. (The bridge at Antietam National Battlefield, photo by author)

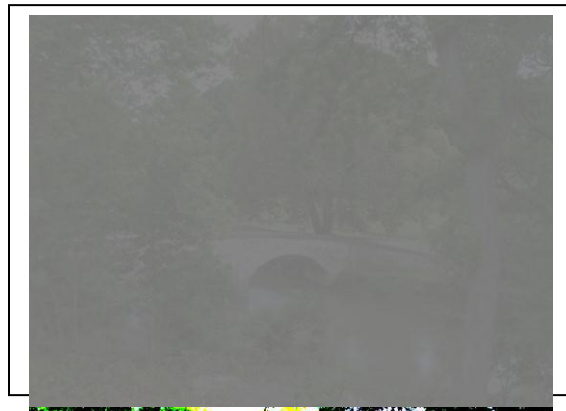
The image created on our retina is much like the image on a computer screen. The overall brightness, or luminance, is determined by the amount of light available. Changing the brightness makes everything either lighter or darker – think of turning the brightness control on your screen; if you lower the brightness, the entire screen darkens; go the other way and the entire screen lightens, but the difference between light and dark remains constant.

Contrast is a measure of the difference between the luminance of an object and the luminance of the area surrounding it. If you turn the contrast control on your computer screen to high, blacks become blacker, whites become whiter, and the mid-range colors begin to disappear. Go the other way and the lines between objects become less intense. Because we are more sensitive to luminance than to contrast, our visual system allows us to see over a wide range of light conditions.

Imagine walking down a busy street during a light misty rain. The objects in front of you are all different sizes, including buildings, signs, adults, and children. Predominant colors are gray, and lighting at best is dim. As the sun sets, there is less contrast, and at some point, all of the objects before you become nearly indistinguishable. The point at which each object becomes indistinguishable is the contrast threshold.

The contrast sensitivity function “is a measure of contrast thresholds for a range of object sizes.”<sup>1</sup> Scientists study this function in the laboratory where a street scene doesn’t easily fit. They use sine wave gratings to simulate real life. A grating is a set of repeating parallel objects that are regularly spaced. The LEA gratings, used for infant testing, are parallel black and white lines – these are high contrast gratings because they use only black and white. A cycle includes one black line and one white line.

Again, our world is not all black and white; shades of gray help us see the fine detail. Instead of high-contrast gratings, scientists use parallel lines that change in brightness over space. These are called sine-wave gratings. Again, one cycle goes from the highest contrast to the lowest contrast. The larger the difference in brightness between the blacks and the whites, the higher the contrast.



The photo at left above shows the bridge at Antietam National Battlefield with the highest amount of contrast, while the right photo shows the same scene with almost no contrast.



<sup>1</sup> Russell L. Woods, PhD, MBO, FAO and Joanne M. Woods, PhD, MBO, FAO. "Contrast Sensitivity Charts and Contrast Letter Charts in Clinical Practice." *Journal of the American Academy of Optometry* (March/April 1995): 43-55 <<http://www.eri.harvard.edu/faculty/woodsr/contrast.htm>>

system has specialized cells that process either large, medium or small objects. We need less contrast to see objects in the mid-range; we need more contrast to see the details in very large or very small objects.

As we age, the ability to clearly see the world around us may begin to diminish, even for those patients with 20/40 or 20/20 visual acuities. Changes may be subtle and unnoticeable at first; the fine outlines may no longer be visible and objects seem to melt into the background. Simple things like not seeing the curb as we step into the street can have devastating effects if we trip and break an ankle or hip.

Certain eye diseases and conditions can affect a patient's contrast sensitivity. Contrast sensitivity has been shown to be reduced in patients with glaucoma, diabetic eye disease, and cataracts.

Evidence collected over the years shows that a loss of contrast sensitivity often precedes visual field loss in glaucoma patients. According the National Eye Institute, open-angle glaucoma affects more than 2 million individuals in the United States<sup>2</sup>. The number is expected to increase to more than 3 million by the year 2020. Patients may continue to exhibit good visual acuity, but contrast sensitivity testing may indicate a lower-than-normal level, or asymmetrical contrast sensitivity between eyes.

Diabetes is a disease that can cause damage to the blood vessels in the eye. Early vascular damage in diabetic eyes is often accompanied by reduced contrast sensitivity. Figures released at the International Diabetes Federation's 20th World Diabetes Congress in October 2009 show that 26.8 million people in the United States have diabetes.

Cataracts, basically a clouding of the lens, result in less light passing through the lens to the retina. Cataract patients may see well enough to score 20/40 on the eye chart, but often complain about their abilities to function in the real world. These patients can easily pass the vision portion of a drivers' license test, but will mention difficulties reading street signs or seeing islands or bumps in the road. Again, complaints may suggest a loss in contrast sensitivity.

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<sup>2</sup>Statistics and Data, "Prevalence of Open-Angle Glaucoma Among Adults in the United States," 2004 Archives of Ophthalmology < <http://www.neih.nih.gov/eyedata/pdb5.asp>>

In an optometric practice we can't take our patients outside to see how well they function in the "real world" with its shadings and optical variations, but we can introduce some very simple tests that will give us a good measure of how well our patients will function in the world outside our offices.

Tests for contrast sensitivity are fairly straightforward. Sine-wave grating tests measure large degrees of the contrast sensitivity function, while available letter tests measure a smaller portion of the function. The selection of one over another is more a matter of choice. According to David Evans, PhD, MBA, founder of VectorVision, the most important element in selecting a contrast sensitivity test for an office setting is "reliability, or the ability to maintain constant test distances and luminance." Aries Arditi, PhD, of Mars Perceptrix echoes this advice and adds that the practitioner must decide which portion of the human contrast function will be tested.

Testing is done with best visual correction in place. Some of the tests on the market use sine-wave gratings to test the contrast sensitivity function. The CSV-1000 offered by VectorVision uses patented circuitry that adjusts for external and internal light to ensure that the test face luminance remains at a constant level. Several faces are available for the instrument, allowing for contrast sensitivity testing as well as ETDRS, Early Treatment Diabetic Retinopathy Study, acuity testing. At a testing distance of 8 meters, patients are shown a series of sine-wave gratings of varying sizes and intensities. An interesting element of some of the screening tests is a series of real-life pictures at the bottom of the testing unit – each picture represents a degree of contrast sensitivity loss. Patients, or their relatives, can easily see the effects of a lower contrast threshold.

Vision Sciences Research Corporation also uses sine-wave gratings in contrast sensitivity testing, offering the Functional Acuity Contrast Test (FACT) Chart. Available as a 27"x37" distance wall chart and a 7"x5" near card, the sine-wave gratings are oriented up and down, to the right or to the left. The FACT Chart is also included in a digital viewer with continually calibrated light levels.

Contrast sensitivity testing gives the optometrist one more measure to help assess a patient's visual needs. It is easily incorporated into the testing routine. Counseling will be required to help a patient deal with those times where low contrast sensitivity will be an issue. The prescription may be changed a bit to accommodate for a loss of contrast sensitivity. A yellow tint on lenses may help increase visual acuity in low-light situations.

At one time, vision specialists believed that contrast sensitivity would never improve; however, a recent University of Rochester study of video gamers found that playing games improved the ability to notice small changes in shades of gray against a uniform background.<sup>3</sup> The study found that expert gamers had better contrast sensitivity than non-gamers. It also found that after intensive training the non-gamers were able to improve contrast sensitivity.

Contrast sensitivity testing provides a comprehensive assessment of everyday vision. Done routinely, it will measure small changes or losses in vision. The results of contrast sensitivity tests will better predict everyday visual performance, as everyday life is full of high and low contrast situations, and everything in between.

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<sup>3</sup>BBC World News. "Video Games can 'Improve Vision'," March 29, 2009 <<http://news.bbc.co.uk/2/hi/health>>



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## PARAOPTOMETRIC RESOURCE CENTER



### *Contrast Sensitivity Quiz*

To receive one hour of continuing education credit, you must be an AOA Associate member, and must answer seven of the ten questions successfully. This exam is comprised of multiple-choice questions designed to measure your level of understanding of the material covered in the continuing education article, "Contrast Sensitivity".

To receive continuing education credit, complete the information below and mail with your \$10 processing fee, \$10 per hour of CE before **December 31<sup>st</sup> of this year** to the:

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**Select the option that best answers the question.**

1. Contrast sensitivity
  - a. is the ability to distinguish objects from each other
  - b. is the ability to distinguish objects from their background
  - c. is the ability to see objects in the dark
  - d. is the ability to see objects in direct sunlight.
2. Our visual system is most sensitive to
  - a. contrast
  - b. luminance
  - c. size
  - d. distance
3. A patient with 20/20 visual acuity
  - a. does not need to be tested for contrast sensitivity
  - b. may have lower than normal contrast sensitivity
  - c. may complain of headaches
  - d. does not need to have sine-wave grating tests



4. The contrast threshold is a measure of
  - a. how bright an object is
  - b. how big an object is
  - c. the point at which an object becomes undistinguishable
  - d. the point at which an object turns black
5. Our visual system needs less contrast to see objects that are
  - a. far away
  - b. at mid range
  - c. very large
  - d. very small
6. Sine-wave gratings are
  - a. parallel lines that do not change in brightness over space
  - b. a set of unparallel objects that are regularly spaced
  - c. a set of parallel objects that are irregularly spaced
  - d. a set of repeating parallel objects that are regularly spaced.
7. Which is NOT true of contrast sensitivity?
  - a. often precedes visual field loss in glaucoma patients
  - b. often is associated with early vascular damage in diabetic eyes
  - c. diminishes with the aging process
  - d. common with all eye diseases
8. One of the main considerations when choosing a contrast sensitivity test is
  - a. the skill of the optometric staff performing the test
  - b. the cost of instrument
  - c. the ability to maintain constant test distances and luminances
  - d. the amount of time needed to perform the test
9. Contrast sensitivity testing on infants should use
  - a. LEA gratings
  - b. FACT chart
  - c. CSV-1000
  - d. Snellen Eye chart
10. What color of tint on lenses may help increase visual acuity in low-light situations?
  - a. green
  - b. blue
  - c. yellow
  - d. rose