Contrast Sensitivity, Glare, and Quality of Vision

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Background

An understanding of what constitutes good or normal vision is fundamental to the eye care practitioner whose goal is to provide the best vision care to his/her patients. Traditionally, performance on the Snellen chart has been used to measure how well a patient sees, with 20/20 vision being the gold standard for what is considered normal. But life is not lived in a refraction lane and an individual's visual demands extend beyond the boundaries of the phoroptor. A "perfect" 20/20 vision measured in the doctor's office may be far from perfect in the real world. Even in the same individual, what is generally considered to be good vision may deteriorate into not-good-enough vision under specific work or environmental conditions.

Perhaps in no other area has the inadequacy of Snellen acuity as the sole determinant of visual performance been recognized as in the evaluation of cataracts. Cataracts are the most common cause of blindness and visual disability worldwide. Cataract surgery is the most frequently performed operation in the United States, with an estimated 2.5 million procedures done annually. Advances in surgical techniques and visual rehabilitation of patients undergoing cataract surgery have greatly increased the pool of mild-to-moderate cataract patients who are potential candidates for this operation. As might be expected, this has led to concerns on the parts of medical and consumer watchdog groups—as well as the federal government, who is largely responsible for picking up the tab for cataract surgery under the Medicare program—regarding the possibility of unnecessary surgery. While Snellen acuity has been the traditional criterion employed for determining when cataract surgery is indicated (with 20/50 or less best corrected acuity being the usual cut-off point for recommending surgery), many practitioners have been forced to deal with patients with better than 20/50 vision, but with significant visual disabilities associated with their cataracts, whom they suspect successful surgery would benefit. Because of this, any number of practical and ethical questions could arise: Who should decide when cataract surgery is indicated: the cataract surgeon, the cataract patient, or the government? When is cataract surgery really necessary? Is 20/50 Snellen acuity a reasonable cut-off point to define visual disability? And, if so, why are some individuals with 20/50 (or even worse) visual acuity satisfied with their vision, while others with better vision are not? Are there more reliable ways to measure functional visual acuity and to determine visual disability than using standard Snellen acuity?

While non-traditional, non-Snellen modalities to assess visual function have existed for some time, their use has been largely confined to the area of vision research. Thoughtful practitioners began adapting these modalities for use in clinical practice. Contrast sensitivity and glare testing were employed as adjuncts to standard Snellen acuity in assessing the need for cataract surgery. Quality of vision (as determined by contrast sensitivity and glare testing) became as important a criterion as quantity of vision (as measured by Snellen acuity) in deciding whether cataract extraction was indicated.

Not surprisingly, accusations were then made that these non-traditional arbiters of visual function were being abused by over-eager cataract surgeons to justify operations when the Snellen acuity appeared adequate, with reports of 20/20 vision cataracts being performed in some cases.

The situation became a public health issue when in 1989 the American Academy of Ophthalmology convened a panel of medical and research experts to determine how to reliably test for acceptable vision and determine visual disability. The result was an Ophthalmic Procedures Assessment, which addressed the role and value of tests other than the standard Snellen acuity—specifically contrast sensitivity and glare testing—in assessing visual function in anterior segment diseases, particularly in cataracts. The report concluded that "…while it is premature to establish definitive guidelines for supplemental tests to visual acuity in assessing the overall visual disability from immature cataracts, contrast sensitivity or low-contrast visual acuity, measured before and after adding a glare source, is probably sufficiently specific and sensitive." It went on to suggest that "…glare tests may be of help in adding to the objective assessment of the impact on visual disability of anterior segment disease."

Resulting clinical interest in the use of contrast sensitivity and glare testing to assess quality of vision has led to the increasing use of these tests in other ocular—and systemic—diseases to determine how various disorders might affect visual function. It has also served to make the eye care practitioner more aware that quantity of vision may not necessarily equate with quality of vision, and to help explain the patient who consistently tests 20/20 in the practitioner's office but remains dissatisfied with his/her vision.

It is important for the eye doctor to realize that there is more to testing—and correcting—vision than using the Snellen chart. Discrepancies between the quantity and quality of vision may signal the possibility of underlying disease. And even in the normal eye, the quality of vision and the visual experience may be affected by non-ocular factors—specifically environmental conditions related to light exposure and modulation—that may be addressed by the judicious use of spectacle lens treatments to provide the patient with the best quantity and quality of vision possible under diverse circumstances. A meticulously performed refraction is the surest way for the practitioner to provide 20/20 vision to the ametropic patient when ocular health allows. The appropriate use of spectacle lens treatments enables the practitioner to go beyond 20/20 with his/her patient and provide the maximum quantity and quality in vision correction.

Snellen Acuity

What Is Snellen Acuity?

The Snellen chart has become something of an ophthalmic icon when it comes to measuring vision. And 20/20, in addition to being considered synonymous with perfect vision, has evolved into a term unto itself, an integral part of our vocabulary. But what is Snellen acuity? What does 20/20 actually mean?

Snellen acuity is all about spatial resolution—the spatial resolution capacity of the central retina, more accurately. Measuring visual acuity indirectly assesses the spatial resolution capacity of the central retina. The higher the spatial resolution, the better the vision. The theory behind letter acuity is directly related to spatial resolution capacity as measured with gratings. A grating consists of spatially repeating light and dark bars. One cycle of a grating consists of one light and one dark bar, and when each bar has a width of 30 minutes of minarc, the grating has a spatial frequency of 1 cycle per degree (cpd). The Snellen chart presents optotypes of gradually decreasing size and correspondingly increasing cpd. The smaller the optotype (or the narrower the equivalent grating or the higher the cpd), the better the acuity. In a 20/20 eye, the equivalent of a 30 cpd grating can be resolved. In a 20/200 eye, resolution decreases to 3 cpd (Figure 1).

In more practical terms, an individual with 20/20 visual acuity is able to recognize letters that are approximately 1/3-inch tall on a Snellen chart from a distance of 20 feet. When vision is less than 20/20, the denominator of the fraction indicates the equivalent distance at which a normally sighted observer can identify the letters. With 20/200 visual acuity, for example, the observer would have to be at 20 feet to identify the same letter that a 20/20 sighted observer could identify at 200 feet.

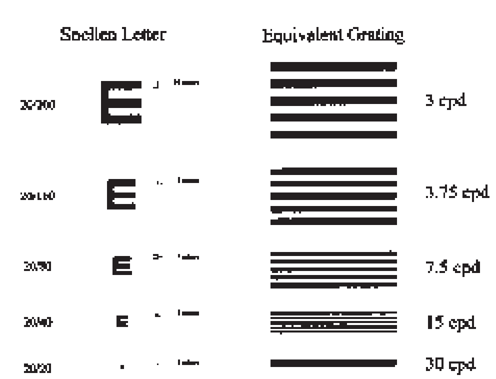

Figure 1. Comparison of Snellen acuity and contrast acuity.

20/20: The Problem With Snellen Vision

One of the problems with standardized Snellen acuity is precisely that it is standardized. In real-world viewing, conditions are not standardized. They vary and these variations can cause a normal 20/20 vision measured under conditions of high illumination in the absence of glare to deteriorate to a far less than 20/20 functional vision when illumination is reduced or glare conditions arise. Simply put, the Snellen chart is in black and white, while the real world exists in shades of gray. It is these shades of gray that need to be addressed in discussing quality-of-vision issues.

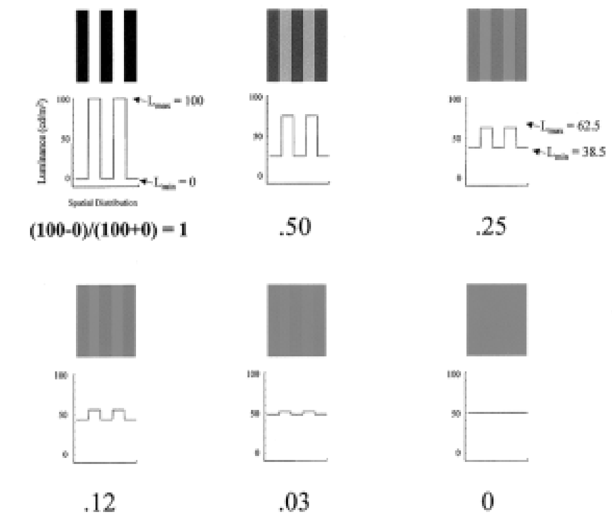

Figure 2. Michaelson formula.

Contrast Sensitivity

What Is Contrast Sensitivity?

If Snellen acuity measures how well the eyes see in black and white, contrast sensitivity acuity measures how well the eye can discriminate the various shades of gray. Contrast is a measure of relative distribution of lighter and darker parts of a visual stimulus. It is defined by the Michaelson formula, which relates the magnitude of the difference in light intensity between the light and dark areas to the overall luminance of the stimulus: (Lmax-Lmin)/(Lmax+Lmin), where Lmax is the luminance of the light bars and Lmin is the luminance of the dark bars (Figure 2). With decreasing contrast, the luminance difference in the grating is reduced until, at some level, the luminance difference is too small to be perceived. This point represents the contrast threshold. Contrast thresholds are normally related to spatial frequency by the contrast sensitivity function (CSF) (Figure 3).

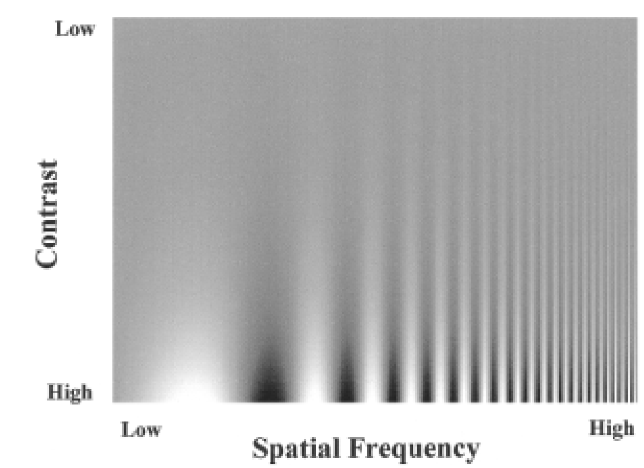

Figure 3. Contrast and spatial frequency.

How Is Contrast Sensitivity Function Measured?

Contrast sensitivity function can be measured clinically using special charts (eg, Peli-Robson and Regan low-contrast acuity charts).

With the Peli-Robson chart, letter optotypes are presented at a fundamental spatial frequency of 0.5 cpd. The chart consists of two groups of three letters per row. The contrast of each letter group decreases from 90% at the top of the chart to 0.5% at the bottom. Subjects are required to read the letters from top to bottom until two of three letters are named incorrectly.

The Regan low contrast acuity test consists of two charts of letter optotypes. The contrasts of the letters are 96% and 11%. All of the letters on a single chart have the same contrast and decrease in size from top to bottom. Subjects read the letters from top to bottom and the smallest identifiable letter is recorded for each chart. Using a nomogram supplied with the charts, a line is drawn between these two acuity measures. Contrast deficits are indicated if the slope of the line is steeper than normal.

Why Is Contrast Sensitivity Important?

The world is a visually complex place. Objects vary in many dimensions, including size, brightness, and contrast. Standard Snellen visual acuity measurements only provide information about high contrast resolution (ie, the smallest, high contrast object that can be seen). Contrast sensitivity testing helps provide important additional information about the visual world. This includes information about the visibility of objects that vary in size, contrast, and orientation.

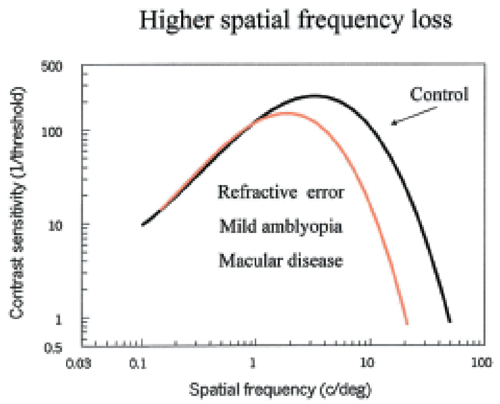

Figure 4. High spatial frequency loss and eye disease.

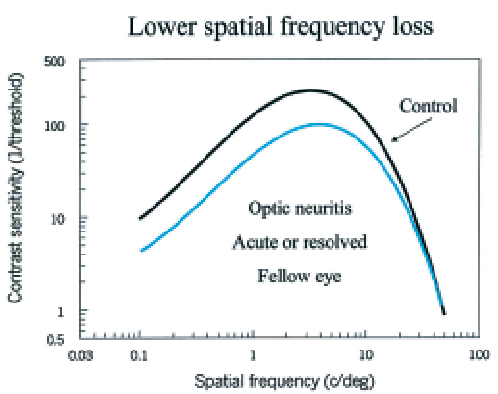

Figure 5. Low spatial frequency loss and eye disease.

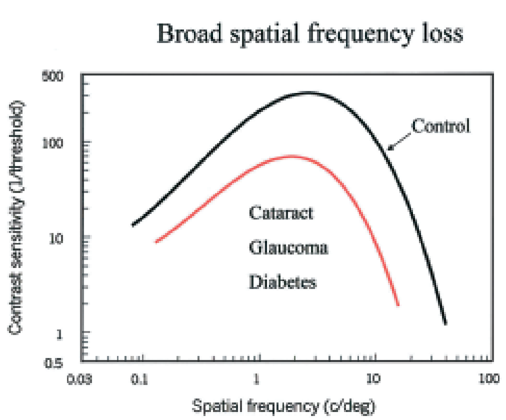

Figure 6. Broad spatial frequency loss and eye disease.

Contrast Sensitivity and Ocular Disease

Perhaps the most important determinant of contrast sensitivity is the health of the eye. A corollary of this is that abnormalities in contrast sensitivity may point to the possibility of underlying ocular disease and alert the clinician to the need for additional testing.

Contrast sensitivity losses can occur at high, low, and broad spatial frequencies. Various ocular and systemic diseases can affect contrast sensitivity functions in different ways and at different frequencies (Figures 4-6). It is especially important in patients presenting with normal Snellen acuity but with persistent visual complaints to consider evaluating contrast sensitivity to rule out possible contributing ocular—or even systemic—disease that might be affecting the quality of vision.

The value of contrast sensitivity testing in assessing visual impairment in cataract patients has already been discussed. However, the usefulness of contrast sensitivity, along with glare testing, in determining the need for cataract surgery with mild-to-moderate anatomical cataracts cannot be overemphasized. With most types of cataracts, a broad spatial frequency loss is encountered.

High spatial frequency losses can be produced by optical or non-optical abnormalities (Figure 4). Conditions affecting the optical quality of the eye that may lead to high spatial frequency losses include refractive errors, mild cortical or nuclear cataracts, and various corneal disorders (eg, edema, irregularities, or opacities) (Figures 7 and 8). Among the non-optical abnormalities leading to high spatial frequency losses are mild amblyopia, macular disease, chronic open-angle glaucoma with moderate visual field loss, and retinitis pigmentosa (RP) in its early stages (Figures 9 and 10).

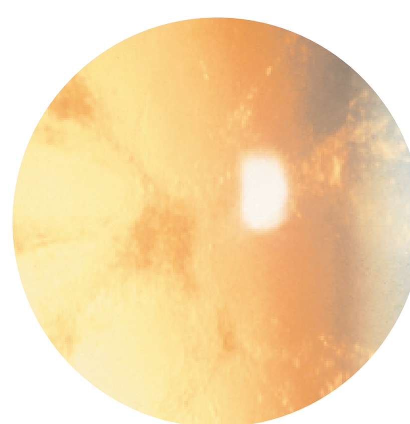

Figure 7. Moderate cataract.

Selective loss at low spatial frequency (Figure 5) is most commonly seen with optic nerve disease, especially in cases of optic neuritis.

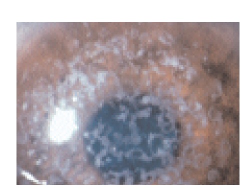

Figure 8. Irregular corneal surface and opacification in a case of granular corneal dystrophy.

Broad spatial frequency loss (Figure 6) is characteristic of moderate-to-severe amblyopia, cataracts, and advanced chronic open-angle glaucoma with widespread field defects (Figure 11).

Figure 9. Macular degeneration.

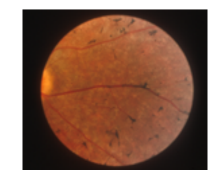

Figure 10. Retinitis pigmentosa. (Slide courtesy of Dr. Irwin Siegel).

Diabetic retinopathy will often produce broad spatial frequency loss (Figure 12). The incidence of diabetes mellitus is assuming epidemic proportions in the United States at this time, with an estimated 17 million Americans currently affected; of these, roughly 5.9 million are undiagnosed. An average of 5 years may elapse before the onset of type II diabetes and its clinical recognition. Because of the strong association between diabetes and ocular disease—particularly diabetic retinopathy—the eye care practitioner must be aware that visual complaints may sometimes point to a diagnosis of unsuspected diabetes and screen patients accordingly. This is especially important since diabetic retinopathy produces 12000-14000 cases of potentially preventable or treatable blindness each year.

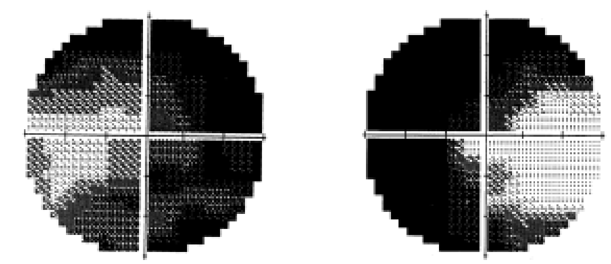

Figure 11. Extensive visual field loss in an advanced case of chronic open-angle glaucoma.

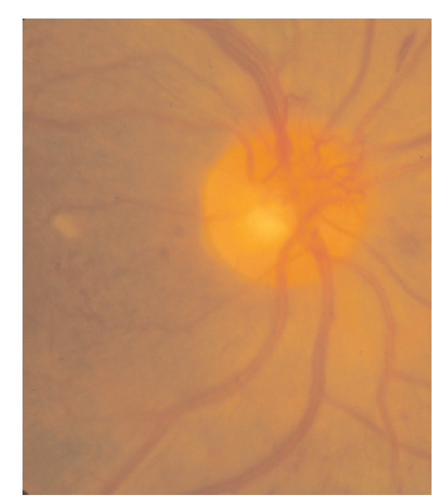

Figure 12. Diabetic retinopathy. (Slide courtesy of Dr. Carol Lee).

In many of the previously mentioned conditions, Snellen acuity will be affected as well, indicating to the clinician that ocular health has been compromised. Occasionally, however, significant ocular disease may not be manifested by changes in Snellen acuity, and it is only after contrast sensitivity is found to be affected that more careful clinical evaluation reveals the presence of such sight-threatening disorders as optic neuritis, RP, or glaucoma.

Contrast Sensitivity and Normal Eyes

The real world is not black and white. It is the various shades of gray encountered in everyday life that make contrast sensitivity crucial in determining how well even a normally sighted individual truly sees. If the properly prescribed modern spectacle lens defines the black and white for the wearer, spectacle lens treatments—such as photochromics and anti-reflection coatings—may serve to fill in the gray in between. And, although contrast sensitivity testing may appear to be primarily a laboratory tool, the fact is that measuring contrast sensitivity acuity clinically is one way to go beyond the simple quantification of vision and gain important information about quality of vision.

Recent research studied the effects of various spectacle lens tints at different levels of transmittance on contrast sensitivity acuity in normal subjects and in those with incipient senile cataracts. The impetus for the research was the realization that while spectacle lens tints are important in attenuating excessive light exposure and promoting visual comfort by decreasing illumination when necessary, the very decrease in illumination that is produced might adversely affect contrast sensitivity. The aims of the study were to determine: 1) if contrast sensitivity function was affected by spectacle lens tints and 2) whether there were differences in how various tints affected contrast sensitivity.

Results demonstrated that all spectacle lens tints tested (gray, brown, yellow, green, purple, and blue) produced an increase in contrast thresholds under glare conditions. There were definite differences in the amount of increase with the various tints, however, and these differences varied between the normal and the cataractous eyes. In the latter, brown or yellow tints caused the least change in thresholds, while in the former, purple and gray tints were preferable. These differences are probably related to changes in clarity and transmission characteristics of the normal versus the cataractous lens.

Glare

What Is Glare?

Glare is the loss in visual performance or visibility, or the annoyance or discomfort, produced by a luminance in the visual field greater than the illuminance to which the eyes are adapted. Luminance is defined in terms of the lumen: a unit of measurement of the amount of light incident on a surface. The higher the luminance, the brighter the surface.

Optimal lighting is in the range of 1000-1400 lumens. Examples of typical environmental luminances include:

Indoor, artificial light	400 lumens
Sunny day, shady side of street	1000-1400 lumens
Sunny day, sunny side of street	3500 lumens
Concrete highway	6000-8000 lumens
Beach or ski slopes	10000-12000 lumens

Glare may come directly from a light source (eg, facing toward the sun) or be reflected. There are four types of glare: Distracting glare, Discomforting glare, Disabling glare, and Blinding Glare.

Distracting Glare

Distracting glare results from light being reflected from the surface of an optical medium. Wherever the incident light moves from one optical medium to another (eg, from air to glass) some of the incident light is reflected. This results in reflections from the lens surface or in the presence of halos around bright lights at night. Distracting glare can represent an annoyance to the viewer and lead to eye fatigue.

Discomforting Glare

Discomforting glare may result from direct or reflected glare. It ranges from 3000 lumens up to about 10000 lumens, at which point the glare becomes disabling. Even mild degrees of discomforting glare produce ocular discomfort, often manifested by symptoms of asthenopia or fatigue. The unprotected eye will respond to discomforting glare by squinting and constriction of the pupil. Often the affected individual will try to avoid the glare by shielding the eyes or turning the head in another direction.

Disabling Glare

Disabling or veiling glare is when the level of light increases to 10000 lumens or more and it produces a glare that can actually interfere with or block vision. This type of glare causes objects to appear to have lower contrast than they would were there no glare. It occurs because the eye is not a perfect optical system due to inhomogeneities in the optical media that lead to light scattering which, in turn, reduces visual acuity and raises the differential light threshold. Disabling glare tends to become more problematic in the elderly, as the decreasing transparency of the crystalline lens that comes with age leads to incipient cataract formation.

Blinding Glare

Blinding glare results from incident light reflecting from smooth shiny surfaces such as water and snow, and becoming plane polarized. It can block vision to the extent that the wearer becomes visually compromised.

How Does Glare Differ From Contrast Sensitivity?

There exists considerable confusion about the difference between contrast sensitivity and glare. This is because glare is used in testing contrast sensitivity. Simply put, contrast sensitivity is about differentiating the various shades of gray. Glare, on the other hand, relates to how it becomes more difficult to differentiate those various shades of gray when illuminance is excessive. Contrast sensitivity tests measure the amount of contrast necessary to recognize a target. Glare sensitivity tests measure the change in visual function that results from a glare source in another part of the field of vision.

How Is Glare Tested?

Glare sensitivity may be tested using contrast detection tasks or by acuity-based measures. The majority of glare tests in current use assess the effects of glare on contrast sensitivity by measuring contrast thresholds in the presence or absence of glare, since veiling luminance reduces image contrast. Acuity-based tests rely on the fact that acuity is affected by changing the contrast of the acuity targets. Targets used in glare testing may be point sources or extended-glare sources. Subjects generally are more comfortable with the latter.

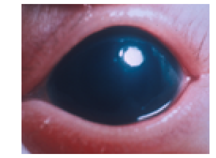

Figure 13. Severe corneal edema in a case of congenital glaucoma.

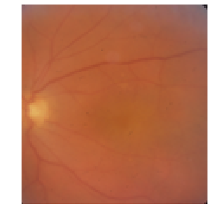

Figure 14. Pseudophakic cystoid macular edema (Slide courtesy of Dr. Carol Lee).

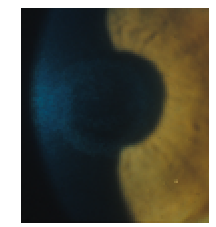

Figure 15. Corneal haze after LASIK (Slide courtesy of Dr. Wilson Ko).

How Does Glare Affect the Normal Eye?

The normal cornea, lens, and vitreous scatter 10%-20% of incident light. Glare is caused by light scatter and is influenced by the dynamics of light-to-dark-to-light adaptation and by retinal photoreceptor saturation. In the normal eye, increasing levels of glare will increase baseline incident light scatter and adversely affect contrast sensitivity. The result is visual discomfort and fatigue.

A frequent complaint in normally sighted individuals relates to difficulties encountered with glare during night driving. Studies have demonstrated that in subjects with healthy eyes, glare sensitivity correlates well with simulated nighttime driving performance.

How Does Glare Affect the Abnormal Eye?

Since glare depends on light scatter in the ocular media, any abnormality or inhomogeneity in the ocular media that further increases intraocular light scatter will increase glare sensitivity. It is generally accepted that glare tests are more specific for anterior segment disorders than simple contrast sensitivity tests. For example, it has been shown that corneal edema produces only minimal effects on contrast sensitivity, but can lead to a threefold increase in glare sensitivity.

Among the ocular diseases which affect glare sensitivity are corneal edema, irregularity, and opacification; cataract and aftercataract; vitreous syneresis; and macular edema (Figures 13 and 14). An area of great interest relating to glare sensitivity at this time is in the post-operative refractive surgery patient. Both with older techniques (radial keratotomy and photorefractive keratoplasty or PRK) and newer laser techniques (LASIK and LASEK), a variety of qualitative vision issues may arise, even in the face of an excellent quantitative (20/20) result (Figure 15). These include problems with night vision, distortion, ghost images, monocular diplopia, and glare. Many of these are attributable to corneal haze and surface irregularities after surgery, producing increased incident light scatter with resultant Discomforting or even Disabling glare.

Photophobia

What Is Photophobia?

Photophobia is a symptom, not a disease. Photophobia, as its name implies, is “a fear of light.” It is not the same as glare, although individuals who are photophobic tend to be more bothered by the effects of glare than those who are not. With glare, it is the amount of light or how it is presented that produces the problem. With photophobia, it is not necessarily the amount or the presentation that is the problem, it is simply the light itself.

Photophobia, or light sensitivity, is one of the most common complaints made to the eye doctor. It should be separated into two categories: pathological photophobia, where there is demonstrable ocular disease to account for the light sensitivity; and non-pathological photophobia, where there is no obvious ocular abnormality to explain the symptom.

Pathological Photophobia

A variety of eye diseases may lead to pathological photophobia. This type of photophobia can be truly disabling, even incapacitating at times, serving to compound the basic visual deficit caused by the underlying disease.

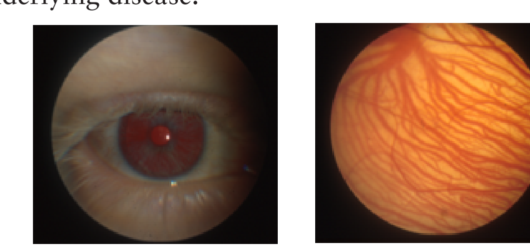

Figure 16 a & b. Ocular albinism: (a) Iris transillumination; (b) Albinoid fundus (Slides courtesy of Dr. Irwin Siegel).

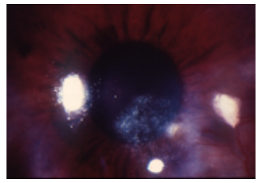

Figure 17. Corneal crystalline deposition in a case of rosacea keratitis.

Probably the most commonly recognized ocular condition associated with photophobia is albinism (Figures 16a and b). The characteristic white-blond hair, brows, and lashes; pale complexion; light blue (almost transparent) irides; hypopigmented fundi; nystagmus; and poor vision usually point to the diagnosis in individuals with this genetic disease.

Certain rare metabolic disorders where crystalline deposits accumulate in the cornea may also produce pathological photophobia (eg, cystinosis). Secondary crystalline or lipid deposition can occur in the cornea as a result of chronic inflammatory disease (Figure 17). Transient irregularities or defects in the corneal surface can induce temporary disease-based photophobia. These clinical manifestations are most commonly encountered in traumatic corneal abrasions. In individuals with severe keratoconjunctivitis sicca and associated corneal epithelial damage, photophobia is a frequent complaint (Figure 18).

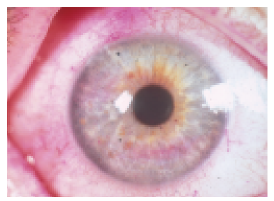

Figure 18. Keratoconjunctivitis sicca: Rose Bengal staining.

Since the iris serves to control the amount of light entering the eye, any abnormality in the structure or integrity of the iris may lead to pathological photophobia. This can develop primarily (eg, in congenital aniridia or mesodermal dysgenesis [Figure 19]) or secondarily, after damage to the iris as a result of surgery, trauma, or inflammation. Pharmacological dilation of the pupil will also cause temporary photophobia.

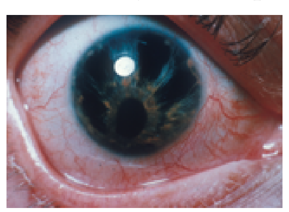

Figure 19. Multiple iris defects in a case of mesodermal dysgenesis.

Non-Pathological Photophobia

Most individuals who complain of photophobia, however, fall into the category of non-pathological photophobia. These are typically the same people who complain of having "sensitive eyes." Although this has traditionally been associated with fair-skinned, light-eyed individuals, there does not appear to be any proven racial or ethnic bias in this regard, with many people of African-American and Hispanic descent having symptomatic non-pathological photophobia. In these individuals, visual acuity is typically normal and there is no obvious ocular pathology to account for the light sensitivity described.

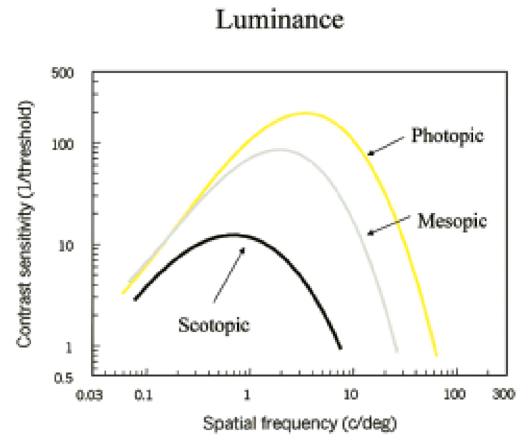

Figure 20. Contrast sensitivity and light conditions.

Optical Solutions

All of the subjects discussed so far share one common element: a problem with light—too much, not enough, the wrong kind, and difficulties with presentation. Actually, they share a second element: the possibility of employing available spectacle lens treatments to correct or alleviate the problem.

A variety of spectacle lens treatments can be used alone or in combination to moderate or modulate the amount and quality of light presented to the eye. They are helpful in alleviating the ocular discomfort resulting from excessive illumination, bothersome reflections, and glare, and, in so doing, serve to enhance both visual comfort and performance. But to work well, these treatments must be used selectively and efficiently.

Contrast sensitivity depends on light levels and is generally optimal under photophobic (ie, daylight) conditions, with contrast thresholds increasing progressively as light dims (mesopic and scotopic conditions) (Figure 20). Filters or tints artificially produce a shift from the photopic towards the scotopic state, with the amount of this shift directly proportional to the density of the tint. The darker the tint, the more the light is filtered, and the greater the shift towards the scotopic side, with a resulting increase in contrast sensitivity threshold and a corresponding decrease in CSF. Tints, then, should be expected to adversely affect vision. But the real-life, real-vision situation is significantly more complicated. Glare is intimately related to contrast sensitivity function (Figure 21). Excessive glare decreases CSF. Spectacle lens treatments that decrease glare should improve contrast sensitivity. So do these treatments help or hinder the visual experience? The answer lies in the balance—the balance between the amount of light and the amount of glare. Depending on the specific illumination conditions, a filter or tint can either facilitate or compromise vision. This is why clear lenses and fixed-tint sunglasses are inadequate and incomplete solutions to the light/vision equation. What should be ideal is not a constant or fixed tint, but an as-needed, on-demand type of light modulation that decreases incident light when levels are too high or glare conditions arise yet allows sufficient light into the eye when levels are lower and glare is not an issue. This is the primary advantage that photochromic (ie, "colored by light") lenses offer to the wearer. These variable tint lenses rely on ultraviolet radiation-induced chemical reactions to produce a darkening of the lens upon exposure to light, with a return to the clear state when the light stimulus is removed (Figure 22). Photochromic lenses are indeed "colored by light" and, with newer designs that are essentially clear indoors or under low light conditions but darken to the level of the standard fixed-tint sunglass outdoors or under conditions of intense incident light, these lenses allow light to work best for the eye and permit the eye to function at its peak under various levels of illumination (Figure 23).

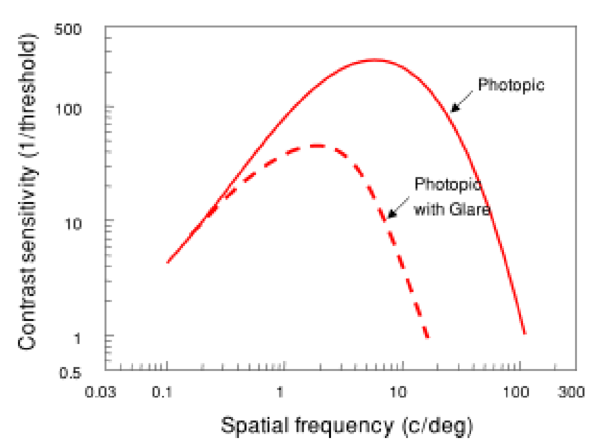

Figure 21. Effect of glare on contrast sensitivity.

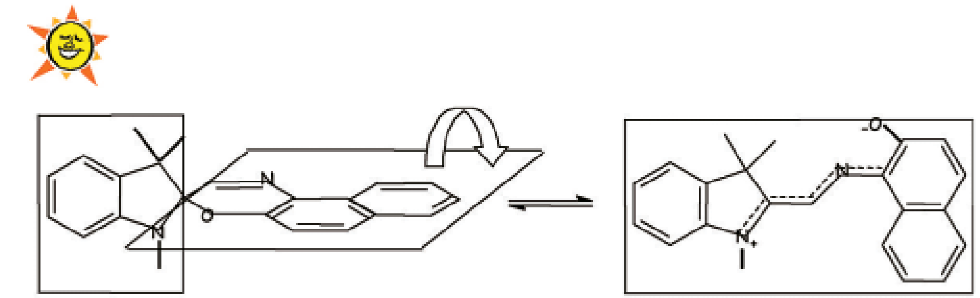

Figure 22. Photochromic chemical reaction.

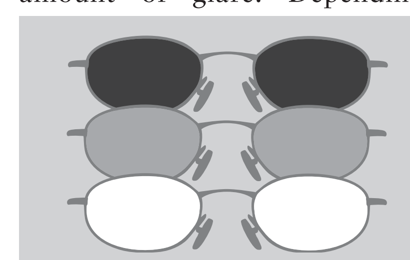

Figure 23. Photochromic lenses: UVR-mediated reaction.

Another useful spectacle lens treatment is the antireflection (AR) coating to reduce Distracting glare. Antireflection coatings function by reflecting light. The reflected light from the lens coating interferes with the light being reflected from the lens substrate or underlying layer. These coatings do not effectively filter out or attenuate non-glare light stimuli and therefore do not shift the photopic-scotopic curves. By minimizing unwanted reflections while still maximizing transmitted light, the coatings enhance the quality of vision while decreasing ocular discomfort under conditions of low-to-moderate light with glare.

The combination of a photochromic lens with an AR coating would appear to be the ideal in achieving the proper balance between illumination and glare to maximize contrast sensitivity function, and offer visual comfort and convenience under varying light conditions.

One other important aspect of light and vision when considering spectacle lens treatments is polarized light. Ambient sunlight is unpolarized. With unpolarized light, the direction of vibration is random (ie, in all directions). When light is reflected from a surface, it is partially or completely plane polarized, with the plane of polarization of the reflected light perpendicular to the plane of incidence of the light. Light incident on smooth surfaces such as glass, concrete, or water produces bothersome polarized light (Blinding glare). This can be eliminated through the use of a polarizing lens oriented

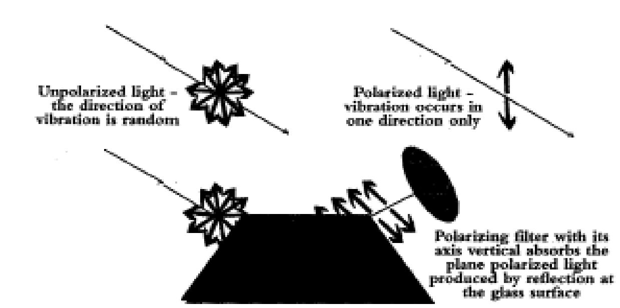

Figure 24. Polarized lenses.

with its vibration plane perpendicular to the reflected light (Figure 24). Polarized lenses eliminate reflected glare, improving the quality of vision and relieving visual discomfort. This is especially important for individuals who work outdoors or enjoy water sports or skiing.

The relationship between light and sight remains a complicated one, but fortunately spectacle lens technology has evolved to the point where there is a spectacle lens treatment or combination of treatments to meet the visual requirements of most people under most circumstances. It is the responsibility of the eye care practitioner to assist the vision care consumer in choosing these treatments wisely.

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