NeoContrast™ **View Assist Technology**

Controlling Optical Wavelengths to Create a Comfortable Field of Vision

— NeoContrast™ Technology —

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Quality of View (QoV) for all

*QoV (Quality of View) is a measure of quality and satisfaction in all areas related to eyes and eyesight in our lives.
The term encompasses vision optimization and comfort, ocular health, and measures to prevent optical diseases.

Mitsui Chemicals

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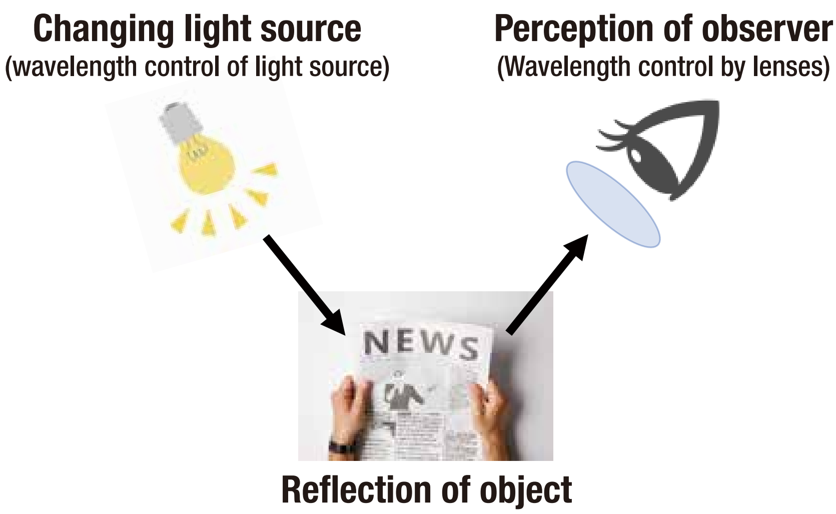
Light is an essential item for our everyday lives and for seeing things. However, this does not mean that the more light we have, the better we can see things. The role of the eye is to capture light and pass a signal onto the visual area of the brain, but photic stimulation is constantly received from extremely far-ranging light wavelength and quantity whether indoors or outdoors. To capture light and achieve a comfortable range of vision, it is necessary to pursue both aspects of "refraction" (function of capturing light and forming a sharp image on the retina) and "optical wavelength control" (function of cutting a certain optical wavelength to improve visual quality and protect the eyes). With regard to the former; the function (refraction) of capturing light from a spectacle lens and delivering sharp images to the retina is already known greatly throughout society. Could the same be said, on the other hand, of the former – optical wavelength control ? Looking at it from a perspective of protecting the eyes from light, the effects of controlling optical wavelengths, such as cutting ultraviolet rays (UV-A, UV-B) and short wavelength blue light (380 to 500nm) from visible rays, have been raised. However, I do not believe that the effects of improving QOV (quality of vision) through optical wavelength controlling and all of its possibilities have been adequately expressed.

When considering QOV, it may also be necessary to take into account not just the vision (sensitivity and resolving power of eyes) of the observer, but also wavelength control by light source (illumination) and by having a lens in front of the eyes (**Figure 1**). When we look at objects, the object is illuminated by light irradiated from the light source, and we recognize the color and shape of the object by making incident the reflected light from the object on the eyes of the observer. If the wavelength of the light source changes, the object's appearance also changes. Similarly, if the wavelength is controlled by a lens in front of the eyes, the object's appearance changes.

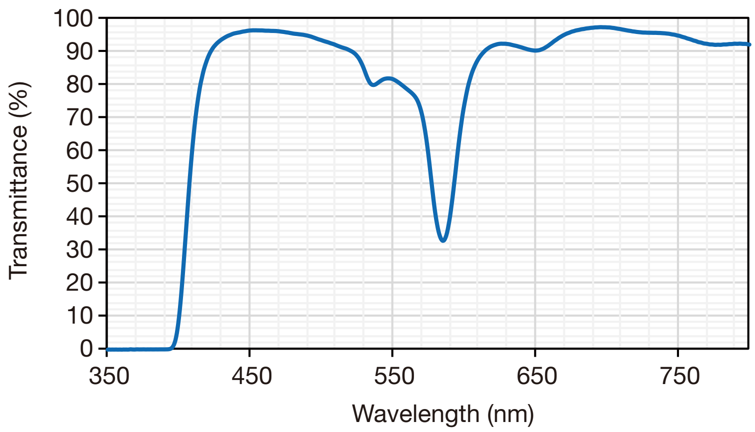
Figure 1
Relationship between Appearance of Objects, Light Source, and Perception of Observers



However, the light environment in our everyday lives is diverse and cannot be adjusted in many cases. However, given that optical wavelength control by lenses (achieving a variety of spectral characteristics by adding coloring matter) can be easily adjusted by putting on and taking off glasses, this is a more practical solution. Lenses that cut short wavelengths (blue light) to lighten photophobia and protect eyes have mainly been used by low-vision patients in the past. NeoContrast™ (Mitsui Chemicals, Inc.) has been developed in recent years as a technique to control optical wavelengths by selectively cutting yellow light (approx. 585nm) (**Figure 2**). Correcting vision by regular eyesight testing at everyday clinical practices is fine, however, middle and old-age symptoms such as "cannot see characters clearly" and "vision is hazy" are experienced. This could be attributed to various causes, but the effects of changing optical characteristics (yellow light) that accompanies the aging process is seen as the main one.

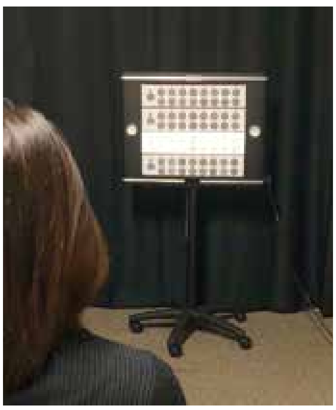
Funamentally, there is a slight yellowing of the crystalline lens from a young age rather than it becoming completely colorless and transparent[1]. With accompaniment of the aging process, there is a yellowing of the crystalline lens and the permeation of the short-wavelength region (blue system) of visible rays of light worsens. The yellowing of the crystalline lens slowly advances as a person ages, so while sense of color adapts and there is no clear awareness of this, the medium and long wavelength region (yellow system) is more pronounced and the field of vision has a yellowish tinge. Due to this, there is an awareness of reduced QOV due to reduced ability to distinguish between subtle colors (e.g. black and navy blue). Sakamoto[2] reported that cutting yellow light was effective in improving contrast sensitivity of middle-aged and older people. NeoContrast™ selectively cuts yellow light (approx. 585nm) from the medium and long wavelength region that becomes more pronounced as people get older, so one could surmise that it could improve

Figure 2 Light Transmittance of NeoContrast™ (Mitsui Chemicals, Inc.)

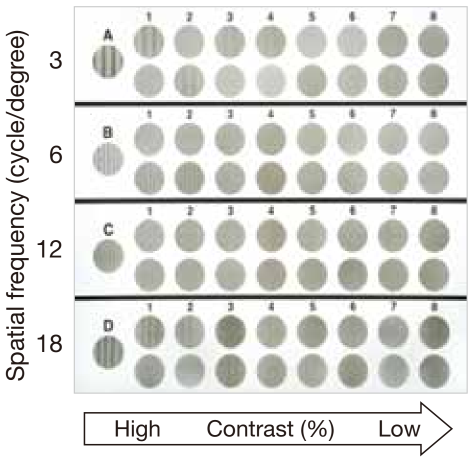


Light Transmittance of NeoContrast™ is shown in the left diagram and an example of NeoContrast™ lenses (sports glasses type) in the right photograph.

Figure 3 Contrast sensitivity testing



CSV-1000 (VectoVison)



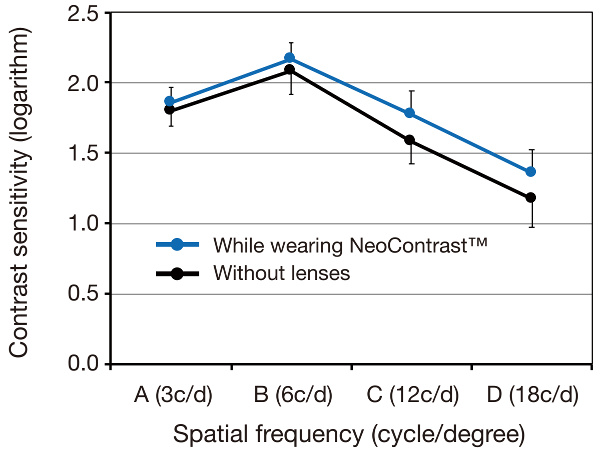
The left diagram shows the appearance of the contrast sensitivity testing instrument (CSV-1000 by Vector Vision).
The right diagram shows the contrast sensitivity testing target (striped target) used by the CSV-1000. The target is set so that the spatial frequency of its striped pattern increases the lower you go, and the contrast reduces the further right you go.
The contrast sensitivity target is divided into a top and bottom with a striped target on one side and a monochrome target on the other. The subjects answer whether the striped target is top or bottom, and contrast sensitivity is obtained from the value of the contrast sensitivity target with the lowest correct answers.

QOV by compensating for the effects of a yellowing crystalline lens that comes with aging.

The most typical method of evaluating QOV is eyesight tests (using clear and high contrast light and shade visual targets), but there is a contrast sensitivity test of "sense of form (form perception)" for eyesight, which is difficult to assess. To test the QOV improvement effects of NeoContrast™, we measured contrast sensitivity using a contrast sensitivity testing instrument (CSV-100 made by VectorVision) on a sample of 15 healthy subjects (average age of 36±6.9 years; corrected vision of 1.0 or more) and 15 cataract patients (average age of 76 ±7.5 years; corrected vision of 0.3 to 0.7) (**Figure 3**). This instrument quantitatively evaluates the contrast sensitivity thresholds of four spatial frequencies (A:3cycles/degree (cpd), B:6cpd, C:12cpd, D:18cpd). Whatever the spatial frequency domain, if the contrast is high (large difference between visual target and background), it is easy to recognize, while characters with a low contrast (small difference between visual target and background) are difficult to recognize. If the contrast sensitivity value is high, this indicates that the subject possesses an excellent sense of form and is able to recognize visual targets with even small lightness and darkness differences (difference between eyesight target and its background). The testing room illumination was set at 500lx.

Contrast sensitivity testing results for the healthy subjects while wearing and not wearing NeoContrast™ are shown in **Figure 4**. Contrast sensitivity while wearing NeoContrast™ is significantly high for 12cpd and 18cpd (Mann-Whitney Rank Sum Test, $p<0.05$) compared to while not wearing it. Contrast sensitivity testing results for the cataract patients while wearing and not wearing NeoContrast™ are shown in **Figure 5**. Contrast sensitivity while wearing NeoContrast™ is significantly high for all spatial frequencies (Mann-Whitney Rank Sum Test, $p<0.05$) compared to while not wearing it. It is necessary to infer the influence in the information processing process of the color in the geniculate body and cerebral cortex from the retina's cone cell (S cone, M cone and L cone) as a reason for the contrast improvement effect due to wearing NeoContrast™. Reduced sensitivity of S, M and L cones accompanied by the aging process has been measured from a psychophysical perspective, and it has been reported that sensitivity decreases together with aging for all cone cells[3]. The influence of changes to crystalline lens optical characteristics becomes greater for the S cone, which possesses spectral sensitivity in a particularly short wavelength range. By selectively diminishing the medium and long wavelength range of approximately 585nm (yellow), NeoContrast™ relatively improves the perception of blue light, which is an antagonistic color[4]. Due to this,

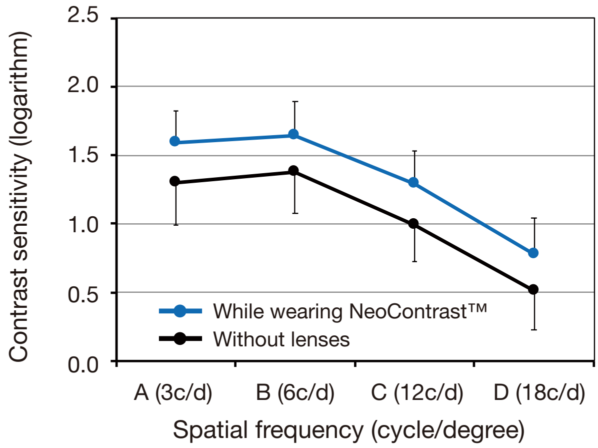
Figure 4
Contrast sensitivity of healthy subjects



∗:Mann-Whitney Rank Sum Test, $p<0.05$

This shows contrast sensitivity while wearing NeoContrast™ and without lenses based on a sample of healthy subjects (average age of 36±6.9 years).
The vertical axis is contrast sensitivity vales (value calculated from inverse of target contrast value (%) is converted to a logarithmic value (log)), which shows that the contrast sensitivity is better the higher the value.

Figure 5
Contrast sensitivity of cataract patients



∗:Mann-Whitney Rank Sum Test, $p<0.05$

This shows contrast sensitivity while wearing NeoContrast™ and without lenses based on a sample of cataract patients (average age of 76±7.5 years).

the color perception balance of contrast sensitivity test targets (**Figure 3 left**) improves (white becomes whiter and the difference between black and white becomes clear) and it can be inferred that there is a possibility that this leads to improved contrast sensitivity results.

To securely maintain QOV in one's everyday life, which is subject to a changing light environment, there is a possibility that optical wavelength control with a lens can help to securely maintain QOV whether indoors or outdoors. The NeoContrast™ being introduced here selectively cuts yellow light (approx. 585nm), so reading printed letters in a newspaper under indoor lighting (daylight color: slightly yellow illumination light, color temperature of 5000K) should become easier and outdoor visibility should improve. Reduced visibility in urban areas due to air pollution is becoming a significant problem, which is leading to even more serious problems such as car and aircraft accidents. **Figure 6** shows changes in visibility in urban areas by wearing NeoContrast™. It is recognized that wearing NeoContrast™ improves visibility by reducing yellowing and improving contrasts. Given that improving outdoor visibility directly helps to prevent car and aircraft accidents, there are hopes that NeoContrast™ can be applied as a traffic safety measure.

With regard to the effects of wavelength control by spectacle lenses, it will be necessary in the future to once again examine the wavelength region to be cut as well as lens strength (transmissivity), and to develop optical wavelength effects that adapt to lifestyle situations and environments. The NeoContrast™ introduced here could be called an innovative lens technology that is the first step to an optical wavelength control effect that can produce an improved QOV effect through improved contrast (visibility improvement).

Figure 6
Changes in visibility in urban areas while wearing NeoContrast™

This shows changing visibility by wearing NeoContrast™ in Indian urban areas (Mumbai: region with a relatively low level of air pollution), which have a serious air pollution problem. Through this lens, yellowing is reduced and contrast (particularly building contrasts) and color vividness is perceived better.

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