Binocular Harmonization Technology & Binocular Eye Model

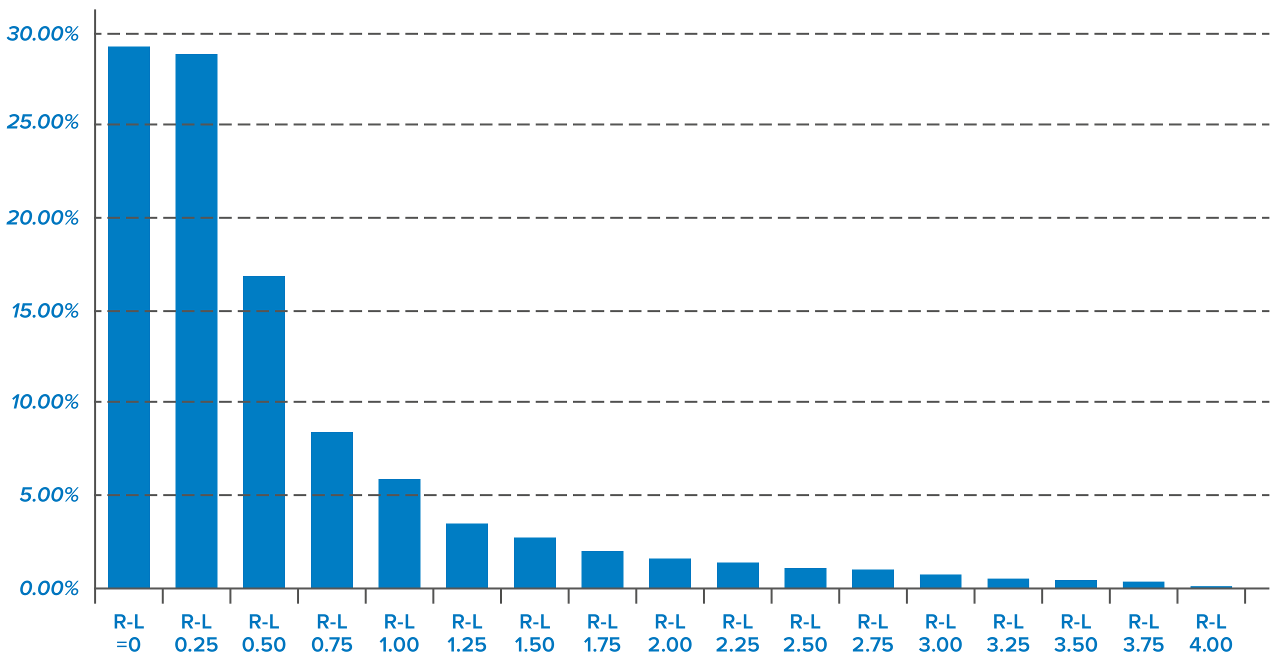
QUESTION

How often do you have patients that are underwhelmed with their new progressive lenses? They state that their vision is clear at near when they cover each eye individually but, are not satisfied or comfortable when viewing reading material at near with both eyes simultaneously. This is a relatively common occurrence – and Hoya now has a unique, patented solution.

SITUATION

Approximately 7 out of 10 presbyopes have a greater than 0.25D difference in the distance prescription for the right and the left eye. Even the smallest prescription difference means that light passing through each lens will be refracted differently. Therefore, the prismatic effect of each lens will be different. The result is a visual imbalance that can cause asthenopic complaints such as unstable blurred vision, tired and burning eyes and headaches. These symptoms are often vague, not directly noted or considered to be related to their lenses.

Difference in total power between the right and left eyes.[1]



[1]Hoya data in file. European progressive lens orders 2007-2013.

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PROBLEM

The problem is caused by the prismatic side effect of an ophthalmic lens and cannot be compensated by the PAL wearer. As a result, each eye will use a different area of the lens when viewing at near. While single vision lens wearers can compensate for this by raising their reading material up, or tilting their head down to look view through the optical center of the lenses when they read, progressive lens wearers must lower their eyes to get into the corridor. As a result, the eyes will experience differing amounts of prism and differing powers of accommodation support.

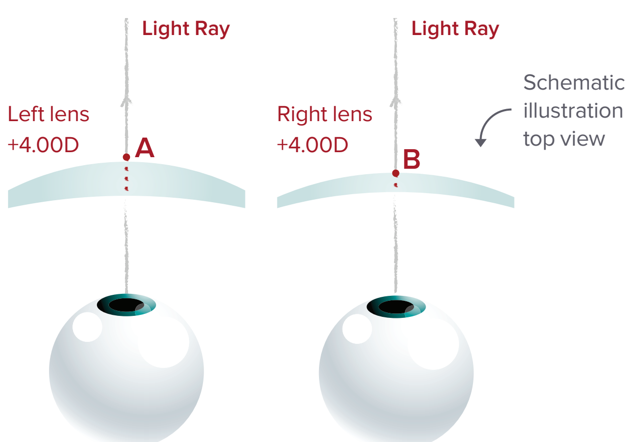
This difference in accommodation support leads to a situation where the image clarity is different for each eye. As a consequence, the brain will try to equalize the image clarity for both eyes, leading to rivalry between the eyes. Because compensation for one eye causes extra blur for the other, all efforts to compensate for this retinal rivalry can lead to asthenopic complaints such as tired and burning eyes and headaches.

Light Rays Passing Through the Lenses Are Refracted Differently

Many people have a different prescription for the right and left eye. Even the smallest prescription difference means that the light rays exit the lenses at different positions for the right and left eye.

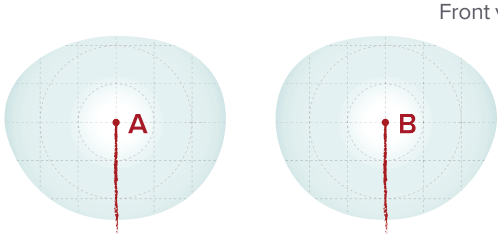
1. Two eyes with different prescriptions focusing on an object at infinity in the central position in front of the eyes.

A and B: position where light ray enters the lenses is the same



2. Light rays exit the lenses at the same position for the right and left eye.

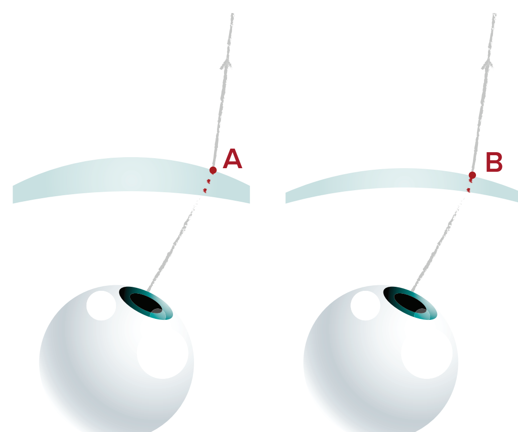
Front view



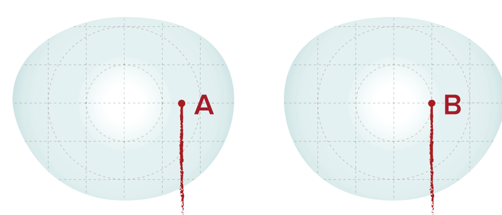
Position where light ray passes through the lenses

3. Two eyes with different prescriptions focusing on an object 4 meters away at an angle of 30 degrees to the right of both eyes.

Prismatic side effect of two lenses with different power



4. Light rays exit the lenses at different positions for the right and left eye. Differing amounts of power will cause differing amounts of image displacement.



Position where light ray passes through the lenses

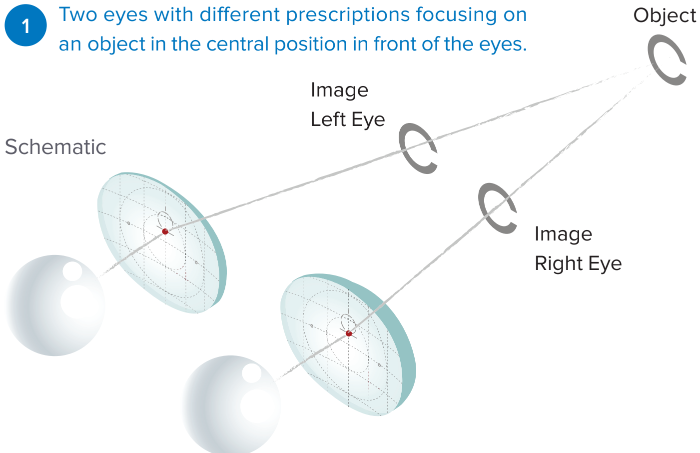
Binocular Harmonization Technology & Binocular Eye Model

SOLUTION

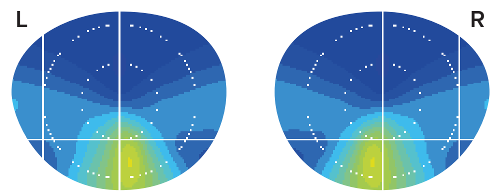
Hoya's patented Binocular Harmonization Technology (BHT) considers the prescription for the right and left eyes as individual components to calculate the optimal binocular lens design, ensuring that the power distribution and progressive corridor of each lens is exact according to the needs of each eye. The result is: perfect and effortless focusing, constant stability and excellent depth of vision.

Introduction on Progressive Lenses

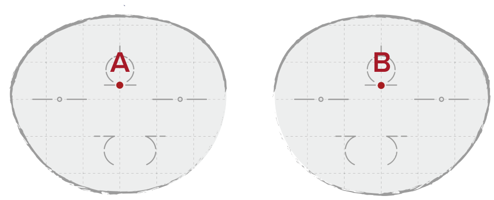
1. Two eyes with different prescriptions focusing on an object in the central position in front of the eyes.



Progressive lenses feature different addition powers in different parts of the lenses.



If both eyes are in the central position, light rays pass through the lenses at the same point. Therefore both eyes experience the same power.



A and B: position where light ray is refracted through the lenses

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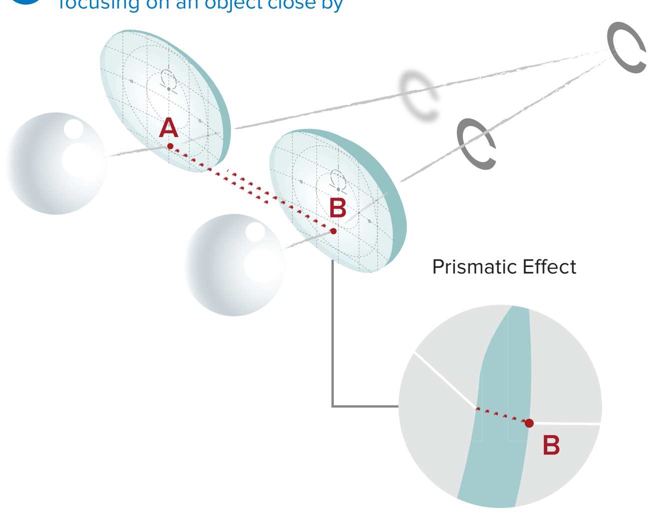
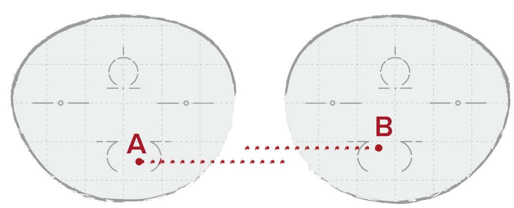
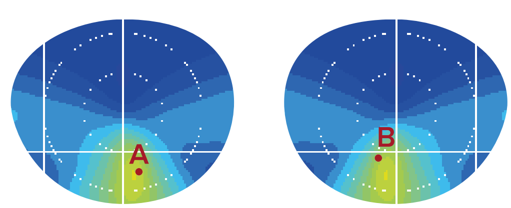
2. Two eyes with different prescriptions focusing on an object close by



Due to different prismatic effects, are deviated at different rates for the right and left eye.



Therefore the eyes experience different addition powers



Even in anisometropic cases, both eyes are using the same point in the upper part of the lens when focusing on an object at infinity, which is illustrated in part 1 on page 4.

When focusing on an object at near, both eyes are looking through different points in the lens. By adjusting the progressive power distribution according to the actual used positions, both eyes will experience the same accommodation support.

Binocular Harmonization Technology & Binocular Eye Model

SITUATION

Hoya has always used several unique evaluation methods to ensure the highest level of correction. However, a method that uses conventional monocular maps is no longer adequate to evaluate the performance of Hoya BHT designs. Hoya has developed five new patented binocular evaluation methods, which are summarized in the Binocular Eye Model. These newly developed evaluation methods focus purely on assessing the binocular performance of the different design variations. These new evaluation methods complement the existing monocular evaluation methods used by Hoya, which are:

Monocular evaluation methods:

- Astigmatic Error
- Mean Addition Power
- Clearness Index
- Deformation Index
- Skew Deformation Index
- Dynamic Deformation Index

The Binocular Eye Model consists of:

- Binocular Clearness Index
- Convergence Difference between R/L
- Accommodation Demand Difference between R/L
- Magnification Difference between R/L
- Vertical Prismatic Difference between R/L

The maps presented in this paper are based on ray tracing technology. This technology makes it possible to trace the path of an infinitesimally small bundle of light rays through the lens. This tiny bundle of light rays can be seen as a circle in object space and changes in shape and size depending on aberrations in the lens. This document provides a basic explanation of how the different evaluation models should be interpreted.

Binocular Harmonization Technology & Binocular Eye Model

SOLUTION

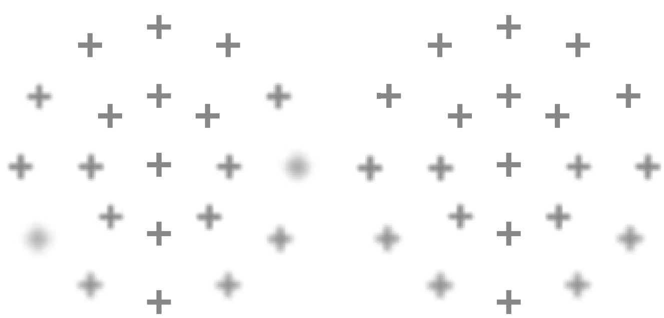
Clearness Index

The Clearness Index describes how clearly the wearer sees an image through the spectacle lenses.

The Binocular Clearness Index expands on the principles that were originally developed for monocular interpretation. The dark blue regions in the Binocular Clearness Index map indicate areas in the lenses (always considered as a pair) where the wearer's visual acuity attains the highest possible value. Logically speaking, the Binocular Clearness Index can only be 1.0 if both Monocular Clearness Indices are 1.0, or extremely close to 1.0. However, the Binocular Clearness Index map will generally show wider clear areas compared to the Monocular Clearness Index. This is because small aberrations in one eye/lens com bination can be compensated for by the other eye/lens combination.

Similarly, if the visual acuity of both eyes individually, when full correction is applied to the wearer's vision, lies below a value of 1.0, the lens will not be able to provide a visual acuity of 1.0 or higher for the wearer. When considered in this way, the map and the values at each point of the lens can also be seen as a factor to be multiplied by. This is the maximum visual acuity possessed by the individual wearer.

Object observed through different positions of the lens



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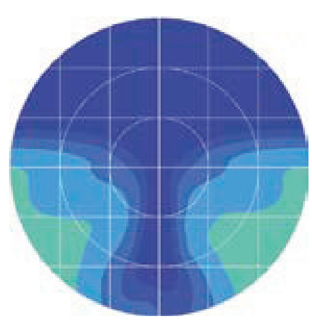
iD LifeStyle 3 w/Binocular Harmonization Technology



Clearness Index (binocular)

The lens pair shown in the comparison is:
L: S +2.00D R: S +4.00D
Addition 2.50, PD 32+32mm

Binocular Harmonization Technology & Binocular Eye Model

SOLUTION

Convergence Difference

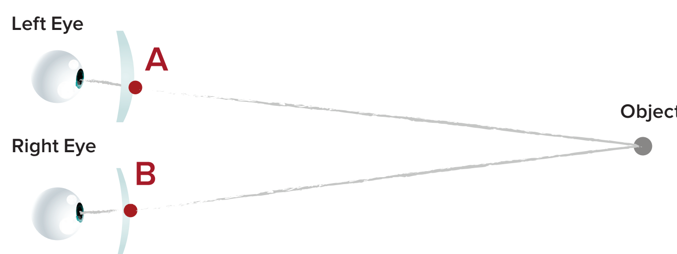
As the Convergence Difference is also a binocular evaluation, we use the same system of coordinates to produce the associated map. The Convergence Difference shows whether the two lens/eye combinations force the wearer to apply either convergence or divergence as a function of the object distance, the power, the power difference and the prismatic difference (due to the power difference).

That our eyes have a natural ability to converge is a known fact. However, performing the opposite movement, divergence, is either impossible, or very difficult. While convergence is natural when viewing an object at near, it is rather inconvenient when viewing an object at optical infinity. This is especially true as convergence and accommodation are linked. This leads us to conclude that convergence in near vision area is desirable, necessary and that both convergence and divergence in the far vision area of the lens may cause complaints. It is also clear however that a difference in vergence is unavoidable, particularly in the case of anisometropic prescriptions, due to different prismatic side-effects of the lens power for each eye. This effect is magnified if the Face Form Angle increases.

Dark blue in the map indicates areas where no convergence or divergence is necessary. Cyan and yellow areas indicate where convergence is necessary. Purple areas indicate that divergence would be necessary.

With Binocular Harmonization Technology, the power difference between the right and left eye are taken into account during lens optimization, thereby significantly reducing the vergence requirements in the binocular state. Note however that controlling the prismatic side-effects that unavoidably arise in anisometropic prescriptions is not the ultimate goal of BHT.

Top View



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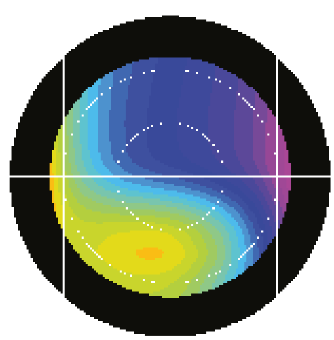
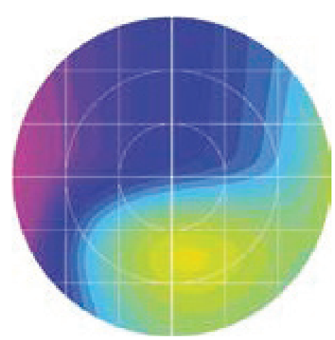


iD LifeStyle 3 w/Binocular Harmonization Technology



Convergence Difference (binocular)

The lens pair shown in the comparison is:
L: S +2.00D R: S +4.00D
Addition 2.50, PD 32+32mm

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SOLUTION

Accommodation Demand Difference

The Accommodation Demand Difference is the most efficient indicator of the effectiveness of Binocular Harmonization Technology. In general, the accommodation demand is the amount of accommodation an eye requires to view an object at any distance and is a function of the object distance, the power of the lens at the point where the light rays pass through the lens and the eye's ametropia.

This map uses the difference in mean power between the right and left eye as well as the binocular object distance to define how much each individual eye must accommodate in order to achieve a sharp, focused image for the relevant object distance. Because a calculation can be made for both eyes, the result can be presented as a difference in accommodation demand between the right and left eye. A difference in accommodation demand of 0.00D can be achieved when the power along the umbilical line (corridor) is matched between the right and left eye. This is possible with Binocular Harmonization Technology.

While a number of smaller areas with unequal Accommodation Demand may still remain, those areas are not used often as they are largely located in the peripheral parts of the lens where the Astigmatic Error is higher. In fact, the astigmatic error partly accounts for this remaining difference in the periphery. Because half of the astigmatic error is combined with the spherical power to achieve the mean power, the resulting power can lead to further differences between the right and left eye, which; lead in turn, to a difference in the accommodation demand.

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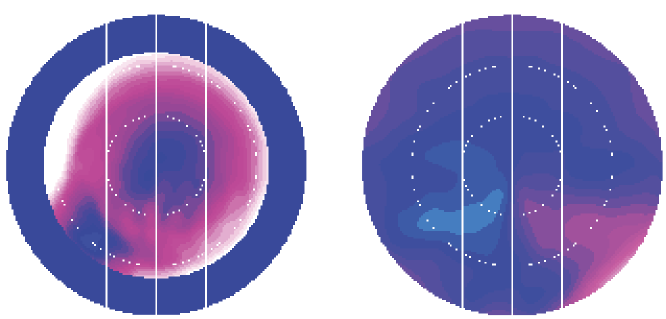
iD LifeStyle 3 w/Binocular Harmonization Technology



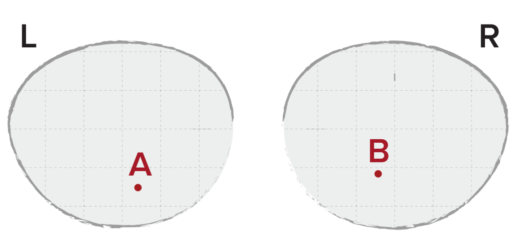
Accommodation Demand Difference (binocular)

The lens pair shown in the comparison is:
L: S +2.00D R: S +4.00D
Addition 2.50, PD 32+32mm

Dark blue indicates areas where the required accommodation difference between the right and left eye would be 0.00D. Dark purple indicates areas where the accommodation demand for the right eye would be higher. Cyan indicates areas where the accommodation demand for the left eye would be greater.

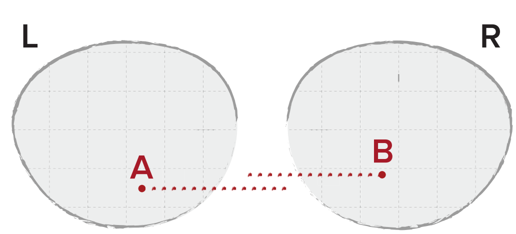
One color change step indicates an increase/decrease in the accommodation demand between the right and left eye of 0.0625D

1. Due to the different vertical prismatic effects the light rays pass through the lens at different positions left and right.



A = +2.50 B = +2.50

2. By repositioning the addition in the lens, both eyes experience the same accommodation support.



A = +2.50 B = +2.50

Binocular Harmonization Technology & Binocular Eye Model

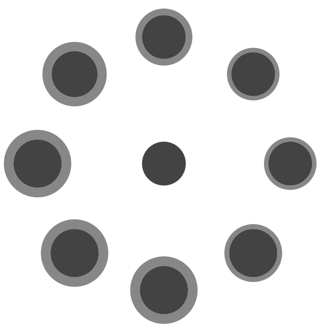
SOLUTION

Magnification Difference

The Magnification Difference displays the difference in spectacle lens magnification for the right and left eye. The spectacle lens magnification mainly depends on the power of the lens, its front curvature and its thickness at the centre. Because the brain has difficulty in merging two images of different sizes, a lower magnification difference between the two images results in better and more stable binocular vision. Even though the overall magnification difference cannot be influenced (due to the difference in prescribed power), improvements can still be achieved in different parts of the lens.

One color change step equates to a 2% increase/decrease in magnification difference. Dark purple indicates a difference of 0%.

Object observed through different positions of the lens



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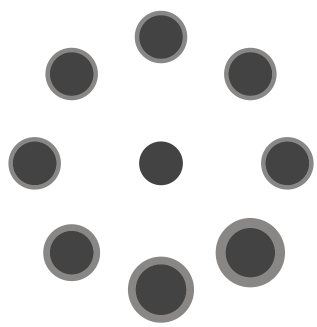
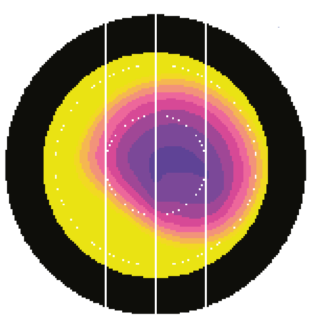
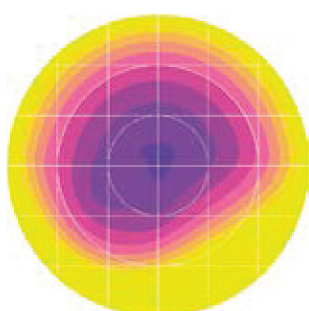


iD LifeStyle 3 w/Binocular Harmonization Technology





Magnification Difference (binocular)

The lens pair shown in the comparison is:
L: S +2.00D R: S +4.00D
Addition 2.50, PD 32+32mm

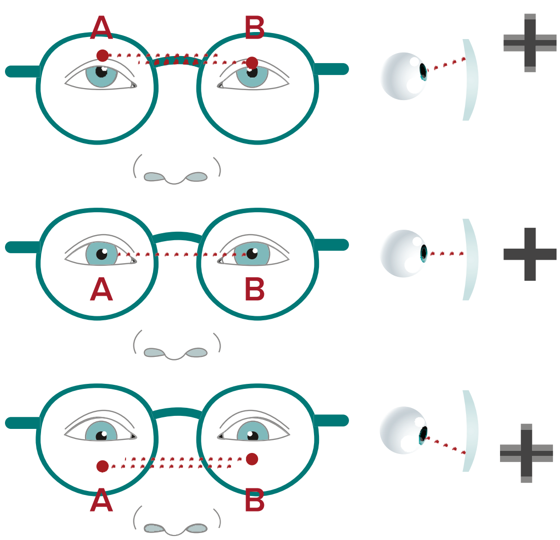
Binocular Harmonization Technology & Binocular Eye Model

SOLUTION

Vertical Prismatic Difference

In addition to the Convergence Difference map referred to previously (which focuses on horizontal eye movement), the Vertical Prismatic Difference presents the different prismatic effects of the pair of lenses in vertical direction. While the general problem remains in anisometropic cases (the prismatic side effects of the lens are still different), the Vertical Prismatic Difference can be controlled to a certain extent by adjusting the progressive pow e r d istribution for each eye individually based on the known power value for each eye. If the power distribution is changed, the actual power at a single specific point also changes, thereby resulting in a different prismatic side-effect. Clearly, the only part of the lenses where the Vertical Prismatic Difference is equal is the area around the prism reference point, particularly in cases of anisometropia.

Vertical prismatic difference illustrated



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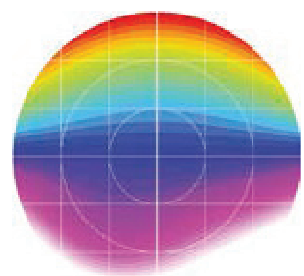
iD LifeStyle 3 w/Binocular Harmonization Technology



Vertical Prismatic Difference (binocular)

The lens pair shown in the comparison is:
L: S +2.00D R: S +4.00D
Addition 2.50, PD 32+32mm

One color change step represents a change in the Vertical Prismatic Difference between the right and left eye of 0.5 prism diopter.

BENEFITS

Hoya's BHT designs:
iD Lifestyle 3
Array 2
iD Space
iD Screen
iD Zoom
All offer perfect and effortless focusing, excellent depth of vision, unprecedented binocular performance and natural, stable vision in all moments that matter.