Effect of Progressive Lens Shape on Space Perception

Presented at the 2012 meeting of the European Academy of Optometry and Optics, this study used virtual reality simulation to compare the degree of swim perceived in dynamic vision by two lens designs: one a traditional progressive lens, and the other a revolutionary new approach to progressive lens geometry.

Introduction

The increase in power from the top to the bottom of a progressive lens creates increasing amounts of prism which induces increasing degrees of image deviation.[1] This distortion becomes most noticeable and most disturbing during dynamic vision, where it produces the well-known "swim effect."[2-4] While optical designers have long worked to minimize "swim," it has been impossible with prior technology to do so without also reducing visual field size.

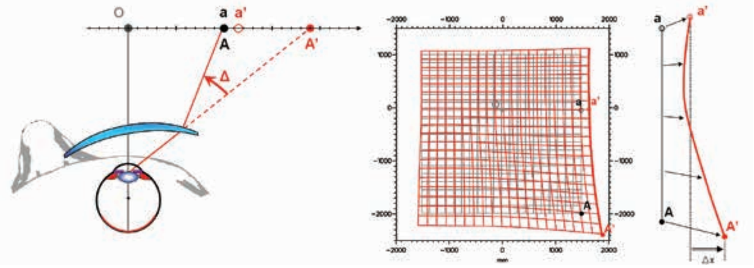

FIGURE 1 Ray tracing enables the image of an object (eg, the gray grid) to be mapped as it would be seen through a progressive lens (the red grid). Note that the lateral displacement from a to a' of an object viewed through the top of the lens is much smaller than the same degree of lateral displacement viewed through the bottom of the lens (A to A').

One can quantify the "swim effect:" The difference in horizontal displacement of a vertical line seen through the upper and the lower portions of the lens is a value we can call Δx. This value is a function of the top-to-bottom change in power and the shape of the lens. By dividing Δx by the maximum power variation ΔP, we can derive an objective criterion of "swim," Δd, which is the *end-to-end normalized deformation*. To minimize "swim," Δd must be close to 0, as it is in a single vision lens.

Challenged to reduce "swim" without decreasing field size, Essilor scientists explored every aspect of the lens design process. The result was a revolutionary new design technology called Nanoptix Technology™, which conceptualizes the lens as composed of tiny optical elements, each of which can be individually corrected to bring Δd close to zero, while respecting the progressive gradient. This study used virtual reality simulation to provide proof-of-concept that this revolutionary lens geometry could produce clinically meaningful results.

Methods

The effects of any given curve on the image of a physical object (eg, a grid) can be mapped (Figure 1) and then modeled in a virtual reality environment (Figure 2).[5] This study used a virtual reality simulator to compare the effects on dynamic vision of two lens designs: a classic progressive lens design and a design with the new geometry designed to reduce "swim."

Using the virtual reality simulator, 10 subjects were shown two images of a grid and asked to compare the images in dynamic vision. Presented in random order, one was a grid as it would be seen through a standard progressive design and the other was a grid as it would appear through the new lens geometry. In each comparison, subjects were asked to state a preference. Each subject made at least four comparisons. Scoring was based on the total number of times each image was chosen as preferred (rather than on individual subject preference).

Results

Comparing the grids in dynamic vision, the grid produced by the optimized geometry was preferred in 62% of the comparisons. The grid produced by the standard progressive design was preferred in 23% (Figure 3). There was no preference in 15% of the comparisons.

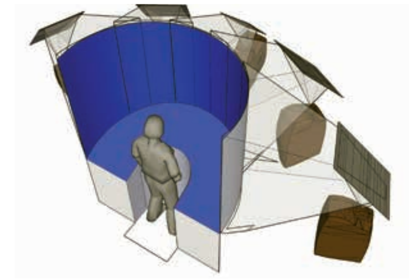

FIGURE 2 The virtual reality testing device's stereoscopic display allows real-time simulation of dynamic binocular space deformation, as seen through virtual lenses when moving the head. *(Courtesy of Barco.)*

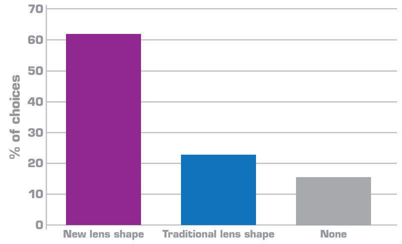

FIGURE 3 In dynamic vision, viewers showed a strong preference for images as they would be seen through the new "swim" geometry compared to traditional progressive lens geometry.

Conclusion

In this study, Essilor vision scientists demonstrated that "swim" could be quantified, and that an innovative lens geometry could provide a clinically meaningful reduction in "swim." Study subjects clearly preferred the virtual reality image provided by the revolutionary new progressive lens geometry to that provided by ordinary progressive lens optics. ■

Based on the poster by C. Guilloux, H. de Rossi, G. Marin, B. Bourdoncle, M. Hernandez, L. Calixte, F. Karioty: "The importance of the ophthalmic progressive lens shape on the space perception" presented at the European Academy of Optometry and Optics Meeting, Dublin, Ireland; April 20-22, 2012.

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1. Simonet P, Bourdoncle B, Miege C. Central and static distortion in ophthalmic lenses. *Vision Science and Its Applications: OSA Technical Digest Series*. 1;1995:31-4.
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The importance of the ophthalmic progressive lens shape on the space perception

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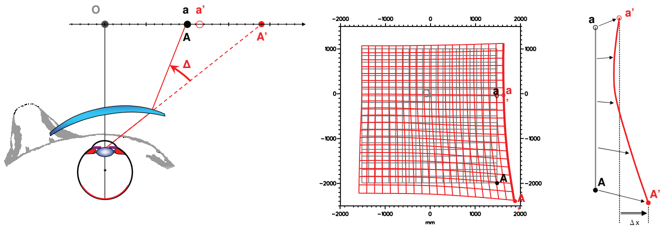
Purpose

Ophthalmic progressive lenses generate space deformation, that is to say distortion of the objects seen through the lens[1]. This is roughly due to power progression in the lens. The most common effect is known as “swim effect” sometimes reported by wearers in binocular and dynamic vision[2,3,4]. It is commonly admitted that these effects are closely linked to the optical properties of the lenses (ie power and aberration repartition), thus establishing a necessary compromise with the fields of vision. The aim of this study was to find and validate experimentally different ways to design an ophthalmic progressive lens in order to minimize space deformation without compromising the fields of vision.

Method

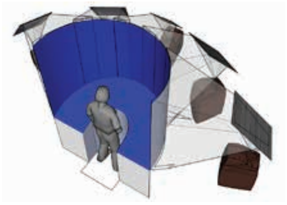
Objective Criteria

Space deformation has been modeled with ray tracing and characterized by optical criteria calculated on distorted grid. We have theoretically evaluated the effects on space deformation for a given design for various geometrical shapes of the lens.



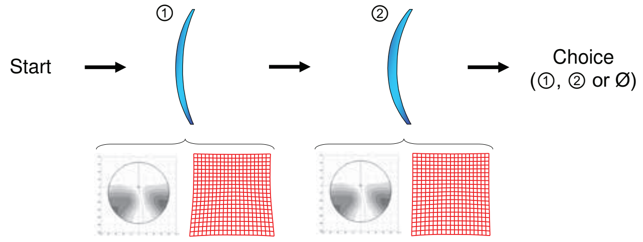
We used a new method of optimization allowing to modify the lens shape while maintaining optical power and aberrations distribution.

Experiment with a virtual lens simulator



Virtual lens simulator allows to simulate the dynamic binocular space deformation seen through virtual lenses in real time when moving the head[5] thanks to stereoscopic display and head tracker.

Ten subjects compared two by two their perception of a grid through different ophthalmic lenses having different geometrical shapes but with exactly the same design, and chose the lens they preferred according to swim effect perception. Presentations were done at random, at least four times per comparison.



Start → ① → ② → Choice (①, ② or Ø)

Results

We show that it is possible to manage space deformation thanks to the shape of the lens without modifying the power and aberrations distribution.

Lens shape can be optimized to reduce “swim effect”

$$\Delta d = \Delta x / \Delta P$$

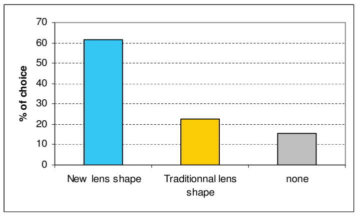
$$Rd = (\Delta d_{①} - \Delta d_{②}) / \Delta d_{②}$$

The objective dynamic space deformation generated by a lens was expressed as the criterion Δd which is the displacement Δx of vertical peripheral object lines divided by the power variation ΔP along this lines. This criteria is relative to the difference in apparent speed of the objects between the upper and lower part of the lens.

The gain Rd of Δd helps to evaluate the performance of lenses having the new optimized shape to reduce “swim effect”. It is about 20% compared to a front surface progressive lens, and even more depending on the prescription.

Effect of lens shape on space deformation is perceived

The experimental study shows that the subjects perceived differences in space deformation among the tested lenses. They mostly chose the lenses with the new shape (62%), compared to the classical ones (23%). In 15% of cases, they did not make a choice.



Among cases of choices (less dynamic space deformation perceived), 73% were in favor of the new type of lenses whereas 27% were for front surface progressive lenses.

Conclusion

In this study, we proved the importance of the geometrical shape of ophthalmic progressive lenses for space perception. Moreover we define a new way of optimizing these lenses. This study leads to the design of new types of progressive lenses having advanced shapes minimizing space deformation without compromising the field of vision.

References

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