Varilux® Live Optics

Only the Varilux® R&D process integrates the results of wearer testing at each stage of lens design, guaranteeing the highest level of patient satisfaction.

1a - Human Vision
Exploring systematically the link between the eye and the brain by drawing on fundamental research in optics and physiology and using virtual reality techniques.

1b - Varilux Virtual Reality
Only Varilux adds this step, allowing many lens designs to be tested BEFORE real-world testing.

2 - Computing
Transforming physiological data into optical design, using 3D wavefront optimization technology.

3 - Prototyping
Prototyping lenses and controlling quality.

4 - Wearer Testing
Testing of the lenses, using double-blind methods and final adjustments on patients.

From Varilux® Physio® to Varilux Physio Enhanced™: Raising the Bar in Progressive Lens Design

Varilux Physio Enhanced™
Technical Paper and Comparative Studies
When they were first introduced, Varilux® Physio® lenses set a new standard, bringing progressive lens wearers an unprecedented level of sharpness at near, distance, and intermediate. Now, Essilor has taken the Varilux Physio design process a step further to create Varilux Physio Enhanced™ lenses, which eliminate even more lens distortion and provide sharper vision over a wider range of lighting conditions. Key to this development is a sophisticated, multifactorial mathemati- cal model that enables optical engineers to design lenses that provide sharper vision, even in low light conditions. As we shall see, vision of this quality in low light is unprecedented in the history of progressive lens design. In addition to exceptional clarity, Varilux Physio Enhanced lenses provide wide fields of vision and can be used in frames that require fitting heights as low as 14 mm, so patients don’t have to sacrifice fashion to get the lenses they want. At the same time, Varilux Physio Enhanced provides a competitive edge to eyecare professionals, who can offer this high-performance lens to patients without making any special measurements or having to buy complex new equipment.

The Evolution of Varilux® Lenses

Ever since 1959, when Essilor introduced Varilux®, the world’s first progressive lens, the company has been dedicated to refining and improving progressive lens design. All progressive lenses aim to provide clear vision for distance, near, and intermediate objects without the use of visible lines or segments, but progressive optics are complex and have their own set of challenges. Over the decades since 1959, lens designers have focused on reducing the aberrations found in the central zones of the lens. These aberrations decreased sharpness of vision and the ability to distinguish objects at low contrast. The effects of higher-order aberrations were particularly noticeable to patients with small refractive errors—they sometimes commented that their vision seemed “sharper” without their glasses. Still, the most pressing problem was peripheral distortion, and that problem occupied optical engineers until the beginning of the current century.

Enter Wavefront Technology

Then, in 2006, Essilor introduced Varilux Physio lenses with W.A.V.E. Technology™: Wavefront Advanced Vision Enhancement. Essilor adapted the wavefront technology developed first by astronomers to eliminate distortions introduced when light from stars passed through earth’s atmosphere. This is also the technology used to drive the lasers in wavefront-guided refractive surgery—in LASIK, the effect of the eye’s optical system on a beam of light entering the eye is analyzed, and this data is then used to program the laser which corrects the cornea to eliminate both large and small optical errors. W.A.V.E. Technology does something very similar. It provides wearers of Varilux Physio and Varilux Physio Enhanced lenses with sharper vision by analyzing the entire beam of light as it passes through the progressive lens (Figure 1). Essilor engineers then identify the specific wavefront distortions and correct them—managing the quality of the wavefront passing through the lens to achieve optimal acuity.

This has resulted in a dramatically improved lens performance. In a 2006 report, McDonald and colleagues compared the capabilities of Varilux Physio with those of conventional progressive lens designs, including the Varilux Panamic®. Compared with the Varilux Panamic lens, Varilux Physio had 3 times fewer higher-order aberrations in the distance field, a 30% wider field of comfortable intermediate vision, and a 10% reduction in maximum defocus in the near zone for a broadened field of near vision acuity.2 Moreover, comparisons to other progressive lens designs showed consistent, and often greater, performance gains at distance, intermediate, and near for Varilux Physio (see Figure B in sidebar on page 5).3

W.A.V.E. Technology has enabled Varilux Physio lenses to provide clinically proven superior visual performance, and only lenses with W.A.V.E. Technology can provide the sharpness and contrast found in Varilux Physio lenses. This is clearly demonstrated in the studies presented in this compendium.

For example, when 81 wearers rated their experiences with Varilux Physio vs a different digitally surfaced progressive addition lens with identical frames and fitting parameters, wearers preferred the Varilux Physio lenses in seven out of eight performance categories, and patients with a prefer- ence showed a 2-to-1 greater preference for Varilux Physio.4 When asked about their plans to buy progressive lenses, 79% chose Varilux Physio.5

In a comparative, double-masked dispensing study, 70 patients compared the performance of Varilux Physio against that of an individualized, digitally surfaced PAL for everyday use.6 Participants evaluated these designs based on several criteria, including near, intermediate, and distance vision, as well as parameters that relate specifically to progressive lens wear, such as zone transition. Because adaptation is an important consideration, wearers were also asked to rate how easily they adjusted to each lens. Overall, wearers preferred the Varilux Physio 4-to-3 over the individualized PAL. As a group, they rated the Varilux Physio lens superior to the individualized PAL in six out of seven categories, including zone transition, near and distance vision, and adaptation to the lens.7 It’s worth reiterating that in this study, Varilux Physio, which needs no specific measure- ments, was preferred to a digitally surfaced individualized lens.

The Arrival of W.A.V.E. Technology 2™

Progressive lens technology advanced again in 2010 when Essilor introduced W.A.V.E. Technology 2™. This exciting new technology employs Essilor’s sophisticated math- ematical model to determine pupil size across a range of add powers, lighting conditions, and viewing distances (Figure 2). By then optimizing the lens design for the expected pupil size, engineers can create a lens that lets patients see optimally in any lighting condition—including the dim light conditions that have traditionally challenged progressive lens wearers.

In fact, most progressive lenses perform adequately under normal daylight conditions when pupils are small, but quality of vision declines noticeably in dim light. This happens because when pupils enlarge, they let in a larger beam of light. This enlarged beam passes through a larger area of the progressive lens, picking up higher order aberrations from the lens. Thus, the larger the beam, the more lens surface it passes through, and the more aberrated it becomes.

To address this problem, Essilor scientists used data from thousands of wearer tests to create the computer model that predicts pupil size over a range of viewing distances and lighting conditions for each patient’s prescription and add combination (Figure 2).
The model then projects each of these pupil sizes onto the lens surface for each gaze direction, to determine potential “use areas” of the lens (Figure 3). The largest pupil diameter is used to determine these use areas; this helps to ensure that all probable use areas are targeted. A use area map is then generated to determine the lens surface based on the largest probable pupil size (Figure 4).

This data is incorporated directly into the lens design, enabling Varilux Physio Enhanced to achieve excellent visual performance at all viewing distances and in all lighting conditions.

Varilux Physio Enhanced™: What Do Wears Think?

To determine whether optimization at the optical bench translates into enhanced patient satisfaction, an independent research group conducted a double-masked, non-dispensing, randomized study in which 30 patients wore either Varilux Physio or Varilux Physio Enhanced lenses while performing various daily activities; these included reading newsprint, using a digital camera, and reading text on a computer LCD screen, in both standard (100 cd/m²) and dim (25 cd/m²) lighting a digital camera, and reading text on a computer LCD screen. The research group conducted a double-masked, non-dispensing, randomized study in which 30 patients wore either Varilux Physio or Varilux Physio Enhanced lenses while performing various daily activities; these included reading newsprint, using a digital camera, and reading text on a computer LCD screen, in both standard (100 cd/m²) and dim (25 cd/m²) lighting conditions.

In dim lighting conditions, 82% of wearers with a preference favored Varilux Physio Enhanced over Varilux Physio. This was statistically significant (P < 0.01). In standard lighting conditions, Varilux Physio Enhanced was also preferred: 71% of the wearers with a preference favored Varilux Physio Enhanced over Varilux Physio, a result that approaches statistical significance (P < 0.08).

The Bench and the Clinic Agree

Comparative data from optical bench testing further highlights the performance capabilities of the Varilux Physio Enhanced lens design. In a comparison of five progressive lenses made of the same material with the same prescription, Varilux Physio Enhanced had the lowest aberration levels, as well as the highest modulation transfer function (a measure of how the lens affects contrast sensitivity) in dim lighting, compared with four different upper-tier progressive addition lenses. It’s clear: wearers prefer Varilux Physio Enhanced because it provides demonstrably better vision.

What This Means for Practitioners

Eyecare professionals want to prescribe progressive lenses that provide the best possible visual performance to their patients. As the findings of these studies indicate, even small changes in visual acuity can make a noticeable difference to wearers.

By offering Varilux Physio Enhanced, practitioners have the opportunity to give patients a quality of vision that will distinguish their practice from the competition. In addition, the ease of adaptation reported in wearer studies suggest that prescribing Varilux Physio Enhanced may reduce the number of nonadapts, potentially decreasing the number of returns.

Enhanced Contrast Sensitivity in Low-light Conditions

Contrast sensitivity enables us to distinguish objects from their backgrounds. This is critical not only for spotting pedestrians while driving at night, but also for driving safely through fog or rain, or being aware of obstacles on the ground when walking outside. Contrast sensitivity also helps us carry out other everyday activities, such as reading a menu or dialing a cell phone in a dimly lit restaurant (Figure A).

Unfortunately, diminished contrast sensitivity is a common problem among progressive addition lens wearers. The complex surfaces of these lenses typically produce higher-order aberrations, and as the pupil expands in dim lighting and allows a larger beam of light to enter the eye, this wider beam passes through a larger area of the spectacle lens. This means the beam is exposed to a greater number of lens aberrations, and these lens-induced aberrations can decrease contrast sensitivity and reduce overall quality of vision (Figure B).

It is also important to remember that, for many patients, appearance is just as important as function. Varilux Physio Enhanced lenses can be fit in just about any frame (fitting heights from 14 mm to 25+ mm can be accommodated). Varilux Physio Enhanced provides the opportunity to increase patient satisfaction while gaining a competitive advantage as a practice that offers cutting-edge vision solutions.

REFERENCES

3. McDiarmid DB, et al. Varilux® Physio® vs. Digitally Surfaced Dual-Surface™ PAL. Enhanced Contrast Sensitivity. Figure A. Of the progressive lens designs tested, the Varilux Physio Enhanced™ lens demonstrated the highest modulation transfer function (MTF) for low light conditions. The higher the MTF, the more faithfully the lens preserves image sharpness.

In a recent consumer study, spectacle lens wearers voiced their desire for better visual performance in low light conditions. Essilor’s patented W.A.V.E. Technology 2™ identifies and corrects aberrations to enhance the performance of the lens and improve contrast sensitivity. And by using a mathematical model that allows the software to optimize each lens made from its minimum pupil size in any condition, Varilux Physio Enhanced™ provides progressive lens wearers with the sharpest possible vision at all distances and in all lighting conditions.

Enhanced Contrast Sensitivity in Low-light Conditions
Wavefront Technology Improves Vision by Reducing Aberrations in Progressive Lenses

Marguerite B. McDonald, MD, FACS,* and the Essilor Study Group**

RESULTS AND DISCUSSION

Intermediate

Coma (Reduced HOA Level) for Enhanced Distance Vision

Amplitude of Zernike Component Astigmatism with an axis of 45°

Wearer Studies Corroborate Wavefront Findings

In a multicenter European study designed to evaluate if a wavefront-optimized design provides better visual function compared with conventional progressive designs, Wavefront Physio™ was compared with standard progressive lenses. Results indicated that Wavefront Physio™ was associated with better visual performance compared with standard progressive lenses.

Considering the Wavefront-Optimized Progressive Lens Designs

As a result, the Varilux Physio lens enhances the quality of the wavefront that reaches the eye.

The Varilux Physio lens was the standard application of wavefront measurement and digital surface technology in the optimization of progressive lens design. Using a patented design and manufacturing process called W.A.V.E. (wavefront advanced vision enhancement) Technology, engineers created Varilux Physio by:

• Patenting a new design and manufacturing process called W.A.V.E.
• Ensuring the lens was manufactured at a constant level of high quality.
• Patenting a new design and manufacturing process called W.A.V.E.

METHODS

The wavefront-optimized Varilux Physio lens was compared with Wavefront Physio™ (Essilor), a standard leading premium progressive lens, by asking those to choose the one that they found to be most comfortable for standard vision and performance. The wavefront analysis involved:

• Lenses of spherical equivalent powers (with a 0.00 D add and standard 1.67 index) in each design.
• Assessing pupil sizes consistent with human ocular function when viewing objects at 5° (1.0 diopter), 10° (2.5 diopter), and 7° (5.0 diopter).

The Varilux Physio lens was chosen by the participants in the study.

The wavefront-optimized lens had lower maximum defocus and deviation from the vertical 90° axis for near vision.

Coma: Wavefront Optimized Conventional

Distance

Conventional

Wavefront Optimized

Figure 1 Wavefront analysis through 3-mm pupil showed that the wavefront-optimized progressive lens design (left) exhibited a smaller wavefront in HGA in the distance field compared to the conventional lens (right). Quantitatively expressed, the wavefront-optimized lens had an HOA level 2.5x lower than the conventional lens.

Figure 2 The HOA level in the distance field of the wavefront-optimized lens design was 0.65x lower than measured in conventional progressive lens designs.
Wavefront-Optimized Progressive Lens Design with Pupil Size Modeling Enhances Low-Light Vision for Presbyopes

— Marguerite B. McDonald, MD, FACS

Recent data shows that Varilux Physio Enhanced™ provides improved vision, particularly in low light.

Progressive addition lens wearers face a common problem: decreased acuity in dim lighting conditions. While everyone’s vision is diminished in dark, low-contrast situations, progressive lens wearers have a unique predicament: As the pupil expands in dark settings, a larger beam of light enters the eye. This wider beam utilizes a larger area of the spectacle lens, and as more of the aberrations inherent in the lens cause wavefront distortions in the beam. This can result in reduced contrast sensitivity and diminished quality of vision.

Varilux Physio Enhanced™: A New Benchmark in Progressive Lens Design

At the annual meeting of the American Academy of Ophthalmology in October 2010, I presented on a poster on Varilux Physio Enhanced™, a new wavefront-corrected progressive lens design that incorporates pupil size modeling data for improved low-light vision. The full poster, “Factoring Pupil Size Changes into a Wavefront-Optimized Progressive Lens Design Improves Vision in Low Light Conditions,” is included on the following pages.

Varilux Physio Enhanced™ uses W.A.V.E. Technology 2™ to identify and manage distortions. Built on earlier W.A.V.E. Technology™: Wavefront Advanced Vision Enhancement, which minimizes the amount of distortion caused by light passing through the lens, W.A.V.E. Technology 2™ incorporates pupil size modeling. This complex model allows designers to fine tune the design to provide the sharpest possible vision for all patients in all lighting conditions.

Cumulative results from a double-masked wearer study and optical bench testing suggest that, compared with progressive lens designs that do not incorporate pupil size modeling, the Varilux Physio Enhanced™ lens provides superior vision, with the greatest benefit seen in low lighting conditions.

The Importance of Contrast Sensitivity

These findings have important implications, as contrast sensitivity is a vital component of visual quality. Numerous everyday activities require the ability to discern objects, depth, and dimensions under low-contrast conditions. When driving in the rain, fog, or in the evening, for example, we rely on contrast sensitivity to distinguish forms that may blend in with the background, including pedestrians.

The ability to carry out more mundane tasks, such as reading a menu or dialing a phone in a dimly lit restaurant, also contribute to quality of life. Although some patients are more sensitive to changes in contrast sensitivity than others, the fact that we are now able to provide this added benefit marks a new achievement in progressive lens design.

Clearer, Crisper Vision, One Innovation at a Time

Progressive addition lenses have come a long way, with each incremental advance providing better vision for our patients. In addition to the breakthrough in pupil size modeling, Varilux Physio Enhanced™ lenses achieve higher levels of sharpness by customizing the design to patient prescription and viewing distance. This level of sophistication means that our patients can enjoy safer night driving and less strain during daily activities such as reading, television watching, and computer use. The design and quality of vision eases adaptation and helps ensure the one thing we all want: happier patients.
Factors Pupil Size Changes into a Wavefront-optimized Progressive Lens Design Improves Vision in Low Light Conditions

Marguerite B. McDonald, MD, FACS*, and the Essilor Study Group**

**PURPOSE**

Varilux Physio Enhanced® is a new wavefront-guided progressive lens that incorporates pupil size modeling into its design. The study evaluates whether this lens provides better vision, especially in low-light conditions, than other progressive lens designs.

**Effects of Pupil Size on Progressive Lens Performance**

A healthy pupil dilates and contracts in response to light levels and distance to the target of gaze. The pupilary response is affected by parasympathetic factors, such as age and anxiety.1 Natural fluctuation in pupil size poses a problem for progressive lens performance. When pupil size increases, as it does in near vision and acuity conditions, the wavefront received by the eye is more highly aberrated because the beam of light passing through an enlarged pupil passes through a larger area of the lens surface (Figure 1). This results in a loss of higher-order optical aberrations, particularly coma, in otherwise lensless designs. Thus, the greater the intraocular lens power, the more the pupil size affects wavefront aberrations. This study investigated wavefront aberrations during contrast sensitivity and visual performance. The effect of pupil size on the lens—i.e., progressive lens performance—was measured via visual acuity and contrast sensitivity.

**METHODS**

A double-masked, randomized, non-prescribing worst first approach compared the new Varilux Physio Enhanced lens to the original Varilux Physio wavefront-controlled lens.

Subjects (N = 30)

- Average age: 52.8 years
- Spherical error: +1.0 to +2.5 D, average = +1.25 D
- Cylinder: ±0.50 D, average = +0.76 D, 10% ±1.00 D
- Axial length: 23.7 mm to 26.7 mm, average = 24.5 mm
- BCVA: 20/25 or better in each eye

**Prior primary mean of surrogate:**
- Distance lenses: 17.2
- Near lenses: 2

**RESULTS AND DISCUSSION**

**Statistically Significant Preference for PAL that Uses Pupil Size Data to Optimize Wavefront**

Subjects preferred the Varilux Physio Enhanced lens in both standard (71%; P = 0.08) and dim (82%; P = 0.006) lighting conditions (Table II). Recorded subject comments referred to “better sharpness/clarity/focus” being experienced with the Varilux Physio Enhanced lens. A similar comparative study of 64 presbyopes confirmed that wearers experienced higher levels of visual performance for all measured criteria with the Varilux Physio Enhanced lens (Figure 3).

**Bench Test Findings**

These computer simulations exhibited reduced wavefront aberration levels (Figure 4) and improved contrast function (Figure 5) when compared to other progressive lenses of similar prescription and material.

**CONCLUSIONS**

The Varilux Physio Enhanced lens was able to maintain better contrast sensitivity in both low light and bright light conditions. This study leads to a higher medication transfer function (MTF) operation based on a lightness value with 47 cd/m² of light and pupil diameters of 3 mm (bright light) and 4 mm (dim light).

1. stepped Pupils are evaluated in bright light conditions. The authors thank the American Academy of Ophthalmology for their support.

**This poster was recognized by the American Academy of Ophthalmology at its annual meeting in 2010.**
METHODS
Subject masked, randomized design, dispensing (duration = 3 weeks/design), identical frames and fitting parameters, AR coated, high-index substrate (1.67 Varilux Physio, 1.60 DS PAL)

Fitting parameters:
• Monocular Pds
• FRP at center pupil
• Minimum fitting height = 18 mm

Each subject subjectively compared designs for:
• Distance (overall preference)
• Intermediate (overall preference)
• Near (overall preference)
• Dynamic Vision (object/subject in motion)
• Visual Fatigue
• Adaptation
• Overall Preference

SUBJECTS
N = 81 subjects

By ametropia
27 Myopes (maximum Rx -6.00)
27 Emmetropes
27 Hyperopes (maximum Rx +3.75)

By astigmatism
23 Spherical Rx
34 Cylinder < 1.00 D
24 Cylinder 1.00 to 2.00 D

Mean ADD = +2.25 (r = +1.00 to +3.00)
Mean Fitting Height = 21 mm (18 to 25 mm)

Current Primary Correction Type
23 = PALS
5 = SV (DVO or NVO)
5 = Contact Lenses (1 monovision, 1 multifocal)

Inclusion Criteria: BVA 20/20 or better in each eye

PURPOSE
To compare the performance of two PAL design technologies:
1. Varilux® Physio®—introduced in 2006—has a front surface digitally molded progression with W.A.V.E. Technology™: Wavefront Advanced Vision Enhancement which reduces and controls higher order aberrations
2. Digitally Surfaced “Dual Surface” PAL—introduced in 2004—has progression digitally surfaced on both the front and the back of the lens to reduce skew distortion

CONCLUSIONS
- Varilux® Physio® lenses were preferred in 7/8 of the areas measured. The results were significantly in favor of Varilux Physio for:
  - distance vision (P < 0.001),
  - intermediate vision (P < 0.01),
  - near vision (P < 0.01),
  - dynamic vision (P < 0.01), and most significantly,
  - subjects with a preference preferred Varilux Physio overall 20:1 (P < 0.01).
- Additionally, when questioned regarding intent to purchase, 79% chose to purchase Varilux Physio.

Clinical Evaluation of Varilux® Physio® vs Digitally Surfaced “Dual Surface” PAL

Research conducted by an independent third party — grant provided by Essilor of America

STATISTICAL RESULTS

<table>
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<tr>
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<th>N = 81</th>
<th>Varilux Physio</th>
<th>DS DS PAL</th>
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<th>P-value</th>
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<td>55</td>
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<tr>
<td>Visual Fatigue</td>
<td>11</td>
<td>3</td>
<td>67</td>
<td>0.061</td>
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<tr>
<td>Overall Performance</td>
<td>40</td>
<td>2</td>
<td>39</td>
<td>&lt;0.001</td>
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</table>

Final Mean Evaluation
Wearers rated satisfaction significantly higher (P < 0.01) for Varilux Physio.
- 10 = Highly satisfactory
- 1 = Very unsatisfactory
Varilux Physio = 9.3 (± 0.8)
DS-DS PAL = 7.5 (± 1.9)

Average satisfaction rating for Varilux Physio lenses was higher and showed greater consistency.
Clinical Evaluation of Varilux® Physio® vs Individualized DS PAL

Research conducted by independent eyecare research organization (London, UK) May 2006–June 2007

METHODS
Comparative, double-masked, dispensing study (each lens design worn 3 weeks)
Evaluation of each lens design recorded through questionnaire after wearing period and comparative questionnaire at the end of the test

Fitting parameters:
• Monocular Pds
• FRP at center pupil
• Individualized lens was individualized according to manufacturer’s parameters (PD, vd, panto, near dist.)

Each subject subjectively compared designs for:
• Distance Vision
• Intermediate Vision
• Near Vision
• Dynamic Vision (subject moving/world moving)
• Visual Fatigue
• Zone Transition
• Adaptation
• Overall Preference

PURPOSE
To evaluate and compare the performance of Varilux® Physio® and an individualized DS PAL for everyday use:
2. Individualized DS PAL — 1.67 digitally surfaced with design individualized to fitting characteristics

SUBJECTS
N = 70 subjects

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<tr>
<th>Refractive Condition</th>
<th>Myopes Total 25</th>
<th>Hyperopes Total 45</th>
<th>Mean ADD = +2.00 ADD (r = +0.75 to +2.75)</th>
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<tbody>
<tr>
<td></td>
<td>5 (&lt;-6.00 to -4.00)</td>
<td>2 (+6.00 to +4.00)</td>
<td>Inclusion Criteria:</td>
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<tr>
<td></td>
<td>9 (-4.00 to -2.00)</td>
<td>13 (+4.00 to +2.00)</td>
<td>&lt; ± 0.50 change from previous Rx</td>
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<tr>
<td></td>
<td>11 (&lt;=-2.00)</td>
<td>30 (&lt;=+2.00)</td>
<td>Corrected VA 6/6 (10/10) each eye</td>
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<tr>
<td></td>
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<td>PAL wearer for &gt; 6 months</td>
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Exclusion Criteria:
Systemic condition having influence on visual acuity
Medical treatment/medication influencing visual acuity

<table>
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<th>Inclusion Criteria</th>
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<td>Near Vision</td>
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<td>Overall Preference</td>
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<td>27</td>
<td>7</td>
<td>0.3135</td>
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CONCLUSIONS
• Overall, subjects preferred Varilux® Physio® 4 to 3 over individualized PAL.
• Varilux Physio was also preferred by more subjects in 6/7 of the specific areas measured (Figure 1). Qualitatively, subjects had a higher evaluation of Varilux Physio for every specific activity measured (Figure 2). Qualitative evaluations were significantly better for vision, comfort, and overall satisfaction (Figure 3).

The data indicates Varilux Physio provides superior performance for everyday visual activities when compared to the individualized DS PAL.
Clinical Evaluation of **Varilux Physio Enhanced™** vs “Individualized” Back Side DS PAL in Dim Lighting Conditions

**PURPOSE**
To evaluate and compare the performance of Varilux Physio Enhanced™ and an individualized DS PAL for use in dim lighting conditions:
1. Varilux Physio Enhanced – digitally surfaced DualOptix lens with W.A.V.E. Technology 2
2. Individualized DS PAL – digitally surfaced with design individualized to fitting characteristics
All lenses were 1.50 plastic with AR coating.

**METHODS**
Comparative, double-masked, non-dispensing randomized conducted in dim lighting conditions (25 cd/m²)

Fitting parameters:
- Monocular Pds
- FRP at center pupil
- Minimum fitting height = 15 mm
- Minimum 10mm between FRP and superior edge of lens

Each subject evaluated designs for three near activities- as well as “overall preference.”
All tasks were measured in dim lighting conditions (25 cd/m²):
- Near Vision – Standard Chart positioned at 40cm (approximately 16”)
- Near Vision – Low Contrast Target (restaurant menu) positioned at 40cm
- Near Vision – Width (column target)
- Overall Preference – Preference based on tested activities

**SUBJECTS**

<table>
<thead>
<tr>
<th>N = 30 subjects</th>
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<tbody>
<tr>
<td>Average age = 53 (age range: 46-64)</td>
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<tr>
<td>Avg. Dist. Rx (OD)</td>
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<td>-1.00 sph (range = -7.00 to +4.50)</td>
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<tr>
<td>-0.72 cyl (range = sph to -2.50)</td>
</tr>
<tr>
<td>Myopes</td>
</tr>
<tr>
<td>15 ( &gt; –0.50)</td>
</tr>
<tr>
<td>Hyperopes</td>
</tr>
<tr>
<td>10 (&gt; +0.50)</td>
</tr>
<tr>
<td>Emmetropes</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>Avg. ADD = +2.08</td>
</tr>
<tr>
<td>Avg. Fitting Height = 19.37 mm (r = 15 mm to 25 mm)</td>
</tr>
<tr>
<td>Current Primary Correction Type</td>
</tr>
<tr>
<td>PALs (6 currently wearing Varilux® Physio™)</td>
</tr>
<tr>
<td>19</td>
</tr>
<tr>
<td>5 SV (DVO or NVO)</td>
</tr>
<tr>
<td>6 Contact lenses</td>
</tr>
<tr>
<td>0 No currently worn correction</td>
</tr>
<tr>
<td>All subjects BVA 20/25 or better in each eye.</td>
</tr>
</tbody>
</table>

**FINDINGS**
In dim lighting conditions (25 cd/m²), subjects preferred Varilux Physio Enhanced lenses over the Back Side DS Individualized lenses. Of the subjects who had a preference, 96% preferred Varilux Physio Enhanced overall for tested near vision activities in dim lighting conditions. This represented a statistically significant finding (P = <0.001).
Subjects also preferred Varilux Physio Enhanced in all three specific areas measured- preferences were statistically significant for both measures of subjective visual quality, and approached significance for near visual width.

**CONCLUSIONS**
- **Varilux Physio Enhanced™** is preferred overall for near vision activities in dim lighting conditions.
- These findings are consistent with the benefit claims of W.A.V.E. Technology 2, which reduces higher order aberrations with wavefront correction customized to the patient’s Rx, viewing distance and lighting conditions.

**STATISTICAL RESULTS**

<table>
<thead>
<tr>
<th>N = 30</th>
<th>Varilux Physio Enhanced</th>
<th>Individualized PAL</th>
<th>No Pref.</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near Visual Quality</td>
<td>19</td>
<td>2</td>
<td>9</td>
<td>0.000</td>
</tr>
<tr>
<td>Near Vision – Menu</td>
<td>19</td>
<td>4</td>
<td>7</td>
<td>0.004</td>
</tr>
<tr>
<td>Near Visual Width</td>
<td>14</td>
<td>5</td>
<td>11</td>
<td>0.067</td>
</tr>
<tr>
<td>Overall Performance</td>
<td>25</td>
<td>1</td>
<td>4</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Effectiveness of W.A.V.E. Technology 2™ — A Wearer Study

Research conducted by an independent third party — sponsored by Essilor of America

METHODS

Double-masked, non-dispensing, randomized
Fitting parameters:
• Monocular Pds
• FRP at center pupil
• Minimum fitting height = 18 mm
• Minimum 10 mm between FRP and superior edge of lens

Each subject evaluated designs for “global overall preference” — in the environments described below under two lighting conditions:
• “Standard” lighting (100 cd/m²)
• “Dim” lighting (25 cd/m²)

Initial Adaptation
• Walking stairs
• Scanning shelves

Distance—scrolling text on two LCD monitors
• Sharpness of text
• Ease of changing focus from central to peripheral monitor
• Width of field

Intermediate—typing text into a Word document imaged on a LCD monitor set at a distance of 60 cm
• Sharpness/clarity of monitor
• Width of field (measured on map displayed on LCD)

Near—use of digital camera, cell phone, restaurant menu
• Ease of use (camera controls, cell functions)
• Clarity (menu, camera, cell)
• Width of field (menu)

Changing Focus—(distance LCD monitor, intermediate LCD monitor, near newsprint)
• Clarity
• Speed/ease of changing focus

Dynamic Vision—(grocery shelves, stairs)
• Finding and reading grocery items and labels
• Confidence on stairs
• Ability to maintain natural posture on stairs

CONCLUSIONS

Varilux Physio Enhanced™ is globally preferred to Varilux® Physio® in all lighting conditions—with preference gaining significance in dim lighting conditions.

These findings are consistent with the claimed benefit of W.A.V.E. Technology 2™ (customized control of higher order aberrations).

SUBJECTS

N = 30 subjects
Average age = 52.9

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<thead>
<tr>
<th>Avg Dist. Rx (OD)</th>
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<tr>
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<td>Avg. ADD = +1.90 (range = +0.75 to +2.75)</td>
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All subjects BVA 20/25 or better in each eye.

FINDINGS

In standard lighting conditions (100 cd/m²), subjects preferred Varilux Physio Enhanced over Varilux Physio. Of the subjects who had a preference, 71% preferred Varilux Physio Enhanced. This preference approached statistical significance (P = 0.08).

In dim lighting conditions (25 cd/m²), subjects significantly preferred Varilux Physio Enhanced over Varilux Physio (P < 0.01). Of the subjects who had a preference, 82% preferred Varilux Physio Enhanced.

During the study, the comments of subjects were recorded. The most frequently occurring comment referred to the “better sharpness/clarity/focus” of the Varilux Physio Enhanced lenses.

Preference and Findings

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<th>Lighting Condition</th>
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<td>8 (27%)</td>
<td>0.006</td>
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PURPOSE

To discern if the claimed benefit of W.A.V.E. Technology 2 (improved vision in all lighting conditions by customizing control of wavefront aberrations) is noticeable in “real life” conditions by actual subjects by comparing the performance of Varilux Physio Enhanced™ to Varilux® Physio®.

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