VARILUX® X series™

WHITE PAPER
& WEARER
TEST RESULTS

VARILUX® X SERIES™ LENSES

THE MOST ADVANCED VARILUX® LENSES EVER

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ABSTRACT

When Varilux S Series™ lenses burst onto the scene in 2012, they were the first and only progressive lenses that virtually eliminated "swim" while maintaining a wide field of vision. These extraordinary benefits were possible thanks to two groundbreaking technologies: Nanoptix™ and SynchronEyes™.

Despite these significant advances, lifestyle changes mean that progressive lens wearers have ever evolving needs. The active presbyope is constantly on-the-go and in need of a lens that will keep their vision sharp at all distances, in every situation. To meet this need, Essilor developed Xtend™ Technology to enable wearers to switch between multiple near distances with unprecedented ease.

Essilor's new Varilux® X Series™ lenses build on the groundbreaking innovations of Varilux S Series™ lenses to meet the lifestyle needs of today's progressive lens wearers in ways they have never experienced before.

In the contents of this paper, the reader will see that Varilux® X Series™ lenses clearly deliver on the promise to provide sharper and crisper vision.

Essilor has engineered the Varilux® X Series™ lens to optimize visual performance for tasks within arm's reach. It has developed its Xtend™ Technology to ensure simultaneous vision of multiple near distances. The result is a high level of visual clarity for activities at all distances, whether sitting and reading a book, using multiple digital devices at a time, or shifting vision between distances while driving a vehicle.

Varilux® X Series™ lenses outperform all other premium lenses and provide wearers with the best vision possible at every distance, even in low light, for every activity.

KEYWORDS:

arm's length vision, near vision, multiple near distances, seamless transitions, acuity model, volume of acuity, peripheral vision, premium progressive lens, Varilux® X Series™, Xtend™ Technology, Nanoptix®, SynchronEyes®, simultaneous vision

3. DOMESTIC PERFORMANCE & WEARER TESTS

Essilor carried out another study in the United States testing the performance of Varilux® X Series™ lenses against Varilux S Series™ lenses. Wearers were given two pairs of eyeglasses, one with Varilux® X Series™ lenses and one with Varilux S Series™ lenses. The frames, materials, and fitting parameters were all identical. Neither the ECPs who administered the test nor the wearers were told which pairs of glasses had which lenses.

Wearers were then asked to complete a variety of tasks that mimic common daily tasks of progressive lens wearers, including reading and typing text on multiple digital devices and shifting visual focus between distant and near objects while driving. While performing these tasks, wearers were asked to compare the two pairs of lenses in terms of visual clarity, visual field, preference, and satisfaction.

The most remarkable results showed that patients preferred Varilux® X Series™ lenses 3 to 1 over Varilux S Series™ lenses for reducing head movement required to find the "sweet spot" in the lenses **(FIGURE 13)**. Additionally, the study showed that nearly 7 out of 10 wearers preferred Varilux® X Series™ lenses for visual comfort over Varilux S Series™ lenses **(FIGURE 14)** and nearly 8 out of 10 wearers preferred the Varilux® X Series™ lenses for transitioning vision between distances **(FIGURE 15)**. Finally, taking into account all of the activities performed, more than 7 out of 10 wearers preferred Varilux® X Series™ lenses overall over Varilux S Series™ lenses **(FIGURE 16)**.

FIGURE 13: PREFERENCE FOR REDUCING HEAD MOVEMENT

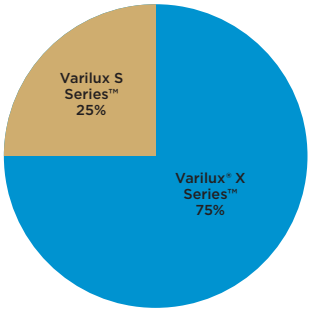

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FIGURE 14: PREFERENCE FOR VISUAL COMFORT

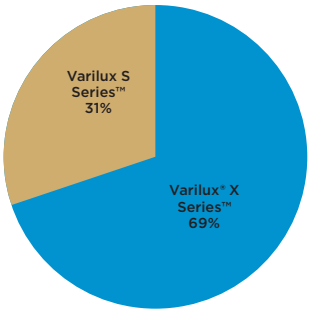

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FIGURE 15: PREFERENCE FOR TRANSITIONING VISION

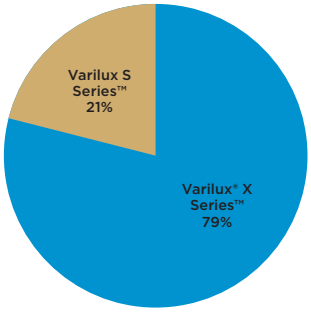

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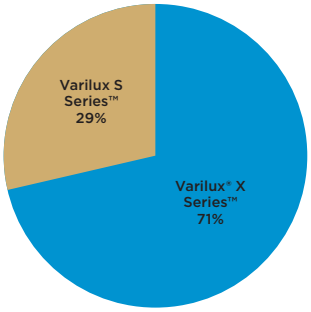
FIGURE 16: OVERALL PREFERENCE



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Sébastien Fricker graduated as a Physics Engineer from Ecole Polytechnique (Palaiseau, France) in 2000 and obtained a masters in electrical engineering from the University of Michigan (Ann Arbor, USA) in 2002. He worked for 10 years in Research and Development in the optical metrology industry. Sébastien joined Essilor Research and Development in 2012, where he works on ophthalmic lens design methods and lens performance modeling.

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I. VISUAL NEEDS & THE LENS/WEARER MODEL

1. MULTIPLE NEAR DISTANCES

For the past two-and-half decades, static situations and reading in seated positions have been the activities studied by research and development professionals and lens manufacturers when optimizing near vision for progressive lenses (Meister, 2006; Cochener, Albou-Ganem & Renard, 2012; Maitenaz & Chauveau, 1999; Miege & Pedrono, 1993; Meslin, 2006).

Varilux Comfort® lenses were optimized according to these methods, with power corresponding to 85 to 100% of the prescribed addition. These values are roughly those needed for reading an A4 sheet of paper at a distance of 16 inches (**FIGURE 1**).

As this conception of near vision is clearly outdated, Essilor R&D has updated it for the digital age by taking into account the many different near tasks and activities that are performed within an arm's length today. In addition to static tasks, wearers today need to be able to multi-task with ease. These varied tasks can be considered to correspond to "multiple near distances".

Varilux® X Series™ lenses are designed to provide simultaneous vision of these multiple near distances between roughly 16 and 28 inches. (**FIGURE 2**). By doing this, Essilor has optimized wearers' vision for multi-tasking within arm's reach.

2. THE VISUAL NEEDS FOR MULTIPLE NEAR DISTANCES

When it comes to near vision, reading is perhaps the most important activity and most demanding in terms of visual performance. It is a central part of our lives in today's society. Not only does it take place in a wide array of environments, with many different types of text and dynamic tasks, but it also requires precise vision and involves accurate eye movements.

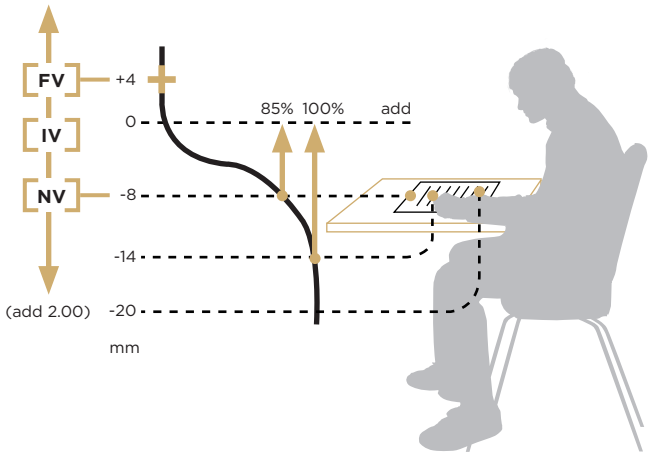
Among other things, it involves perceptual aspects such as letter and word recognition, which are obviously crucial for wearers of progressive lenses.

The reader acquires textual information on several levels: letters, words, and sentences are processed (Perrin, 2015). Visual acuity, as measured by the eye care practitioner (Snellen acuity), is the most important measurement for the reader.

Once the reader recognizes the letter, higher processes involving orthographic and phonological information come into play (Grainger & Ferrand, 1994; Coltheart, Rastle, Perry, Langdon & Ziegler, 2001). Together, they allow the reader to comprehend the elements read.

FIGURE 1. NEAR DISTANCE IN PREVIOUS GENERATION OF PROGRESSIVE LENSES

SINCE THE 90S
A SINGLE NEAR DISTANCE



1 NEAR DISTANCE
1 static plane at 16 in

FIGURE 2. MULTIPLE NEAR DISTANCES WITH VARILUX® X SERIES™ LENSES

2017 VARILUX® X SERIES™ LENS
MULTIPLE NEAR DISTANCES

MULTIPLE NEAR DISTANCES
Sphere within arm's reach

3. VISUAL ACUITY

The eye's ability to perceive and resolve fine details of an object or text is known as visual acuity, and it depends on the clarity of the image projected on the retina. Sharpness of resolution, or Minimum Angle of Resolution (MAR), is commonly used to express visual acuity. MAR represents the minimum angle of separation that enables the eye to distinguish between two distinct objects.

A MAR of 1 arcminute (equal to 1/60 of one degree), which corresponds to 0 LogMAR (i.e. Logarithm of the MAR), is usually considered normal (expressed in feet it equals 20/20 and in meters 6/6). With respect to text and reading, this means the eye is able to make out a letter of which any detail subtends 1 arcminute, assuming the entire letter is five times the size of the detail (**FIGURE 3**).

When reading at a distance of 16 inches, visual acuity of 0.1 LogMAR is sufficient, and at a distance between 20 and 28 in 0.15 LogMAR is enough.

4. ADDITION PRESCRIPTION

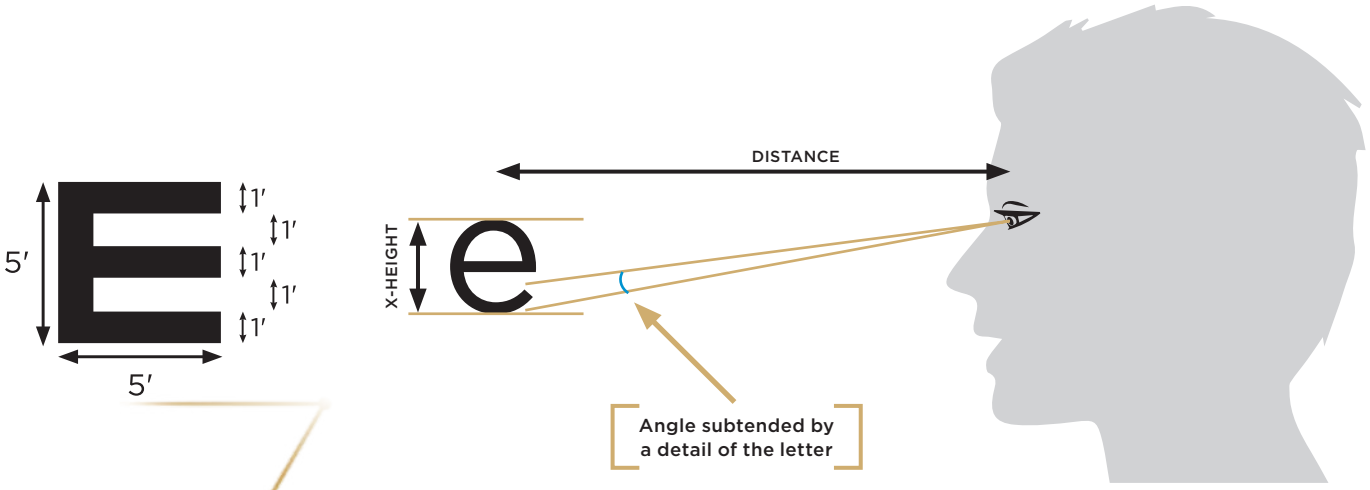
Ametropia must be corrected with the maximum plus for the best acuity. Any undercorrection of hypermetropia or overcorrection of myopia must be avoided so as not to require a higher addition for near vision.

Indeed, the addition prescription is of the utmost importance for visual quality in near vision.

As an individual goes about daily life, their eyes must adapt to the varying distances separating them from objects in their line of sight. This is known as accommodation and allows the eyes to keep objects in sharp focus. Crystalline lens shape modification is the reason for this phenomenon (Millodot, Goumillout & Pouget, 1997).

Addition is the amount of power in diopters (D) that is needed to compensate for a loss of accommodation in near vision. With respect to the latter, this loss typically happens around 40 years of age and results from a hardening of the lens of the eye and its subsequent inability to change shape.

FIGURE 3. MAR FOR VIEWING A LETTER



5. ACUITY MODEL

Essilor has developed a new calculator that is able to manage more complex lens designs. It uses an acuity model to predict the loss – measured in LogMAR – in sharpness of vision when the wearer is looking at a given object through a particular lens. Essilor has perfected its new calculator to take this model into account to generate acuity targets and evaluate the performance of lenses.

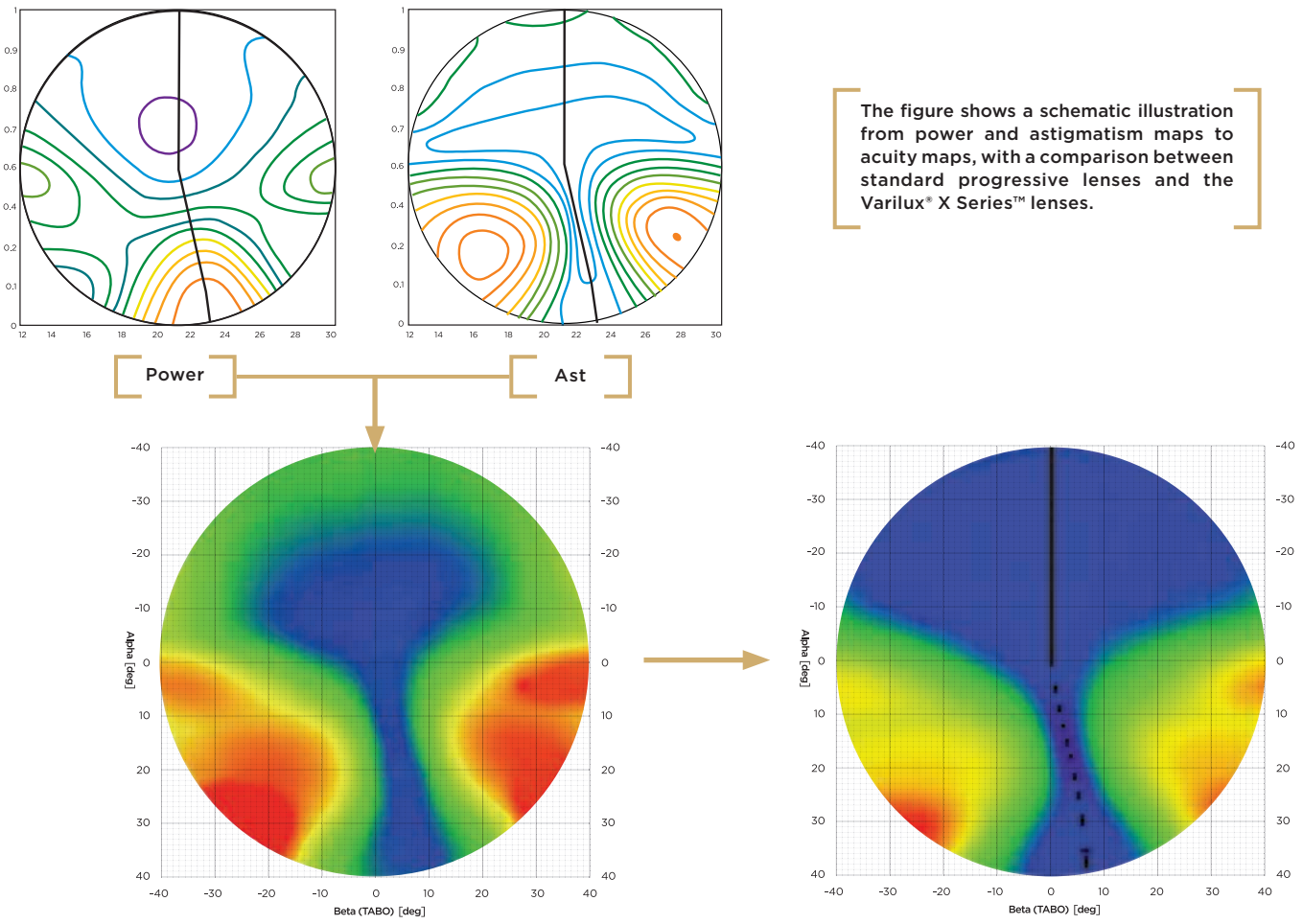
The loss in acuity when a wearer looks through a lens at a given point depends on the following parameters:

- The power of the lens
- The astigmatism of the lens and its axis
- The proximity of the object
- The accommodation of the wearer

In addition to this, the sphere, cylinder, and axis of the lens have a direct impact on the visual acuity performance obtained with the lens (**FIGURE 4**).

The acuity a wearer attains from the use of both eyes is in most cases higher than the best acuity of each eye. This is known as binocular summation and represents a roughly 10% improvement at high contrast.

FIGURE 4. FROM POWER AND ASTIGMATISM MAPS TO ACUITY MAP



The figure shows a schematic illustration from power and astigmatism maps to acuity maps, with a comparison between standard progressive lenses and the Varilux® X Series™ lenses.

Standard progressive lenses

Varilux® X Series™ lenses

II. XTEND™ TECHNOLOGY

1. VISION WITHIN ARM'S REACH

For an individual with a 2.50D addition and no residual accommodation, a distance of 28 inches represents a proximity of 1/0.7, which equals 1.43D. This means about 60% of the total prescribed addition is used for what is generally considered to be in the intermediate vision zone.

The zone of the lens that corresponds to between 60 and 85% of the addition – and is often included in what is referred to as vision within arm's reach – is neither intermediate nor near. This new vision zone complements the typical near vision zone (**FIGURE 5**). As such, it is more and more important in today's digital world, with devices often held within arm's reach.

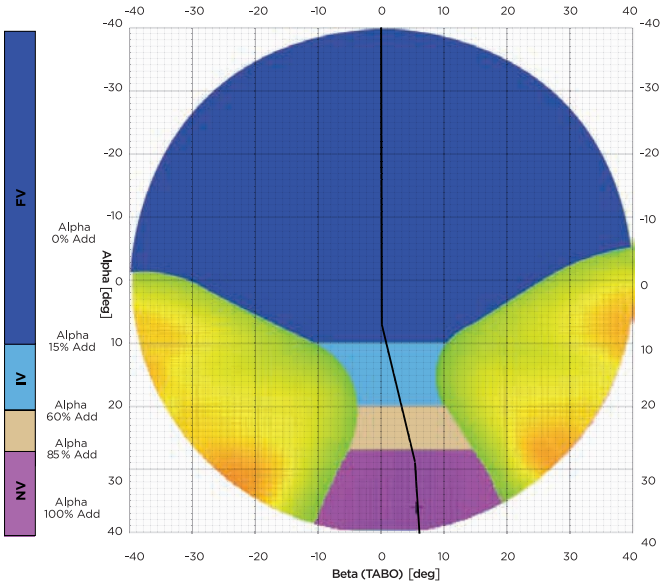
2. XTEND™ TECHNOLOGY

For a wearer of progressive lenses, visual acuity for multiple near distances is clearly paramount. Simply put, the proper acuity for the different distances will allow the wearer to seamlessly transition from one near distance to another when looking at objects within arm's reach.

To achieve this, Essilor has developed its Xtend™ Technology to greatly enhance the Varilux® X Series™ lens' performance with the multiple near distances – and in particular with vision within arm's reach. It generates uniquely optimized acuity buffers that temper each addition variation to boost depth of field and enhance the local surface shape to widen the acuity volume and provide simultaneous vision of multiple near targets.

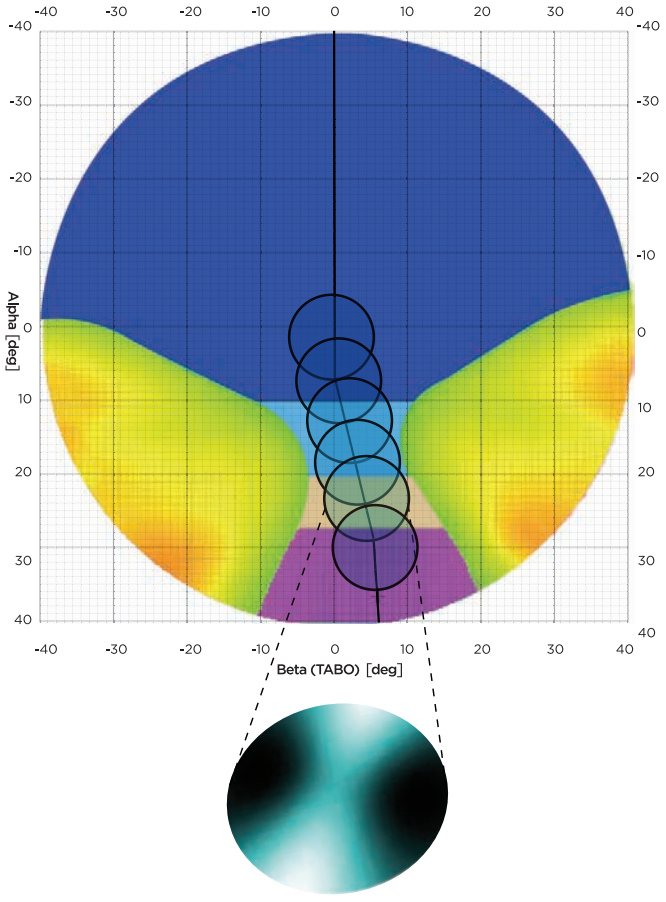
By targeting the wearer's acuity value, Xtend™ Technology maintains the highest level of sharpness for each distance and as a result maximizes simultaneous vision of multiple near distances.

FIGURE 5. MULTIPLE NEAR DISTANCE ON AN ACUITY FIELD MAP FOR A -3.00 LENS WITH A 2.00 ADD



FV (Far Vision) represents less than a 15% addition, IV (Intermediate Vision) is between 15 and 60%, Vision within Arm's Reach 60 and 85% and NV (Near Vision) represents an addition from 85 to 100%.

FIGURE 6. THE ACUITY BUFFERS ON THE SURFACE OF A VARILUX® X SERIES™ LENS



III. THE PERFORMANCE OF THE VARILUX® X SERIES™ LENS

1. OPTICAL PERFORMANCE OF THE LENS

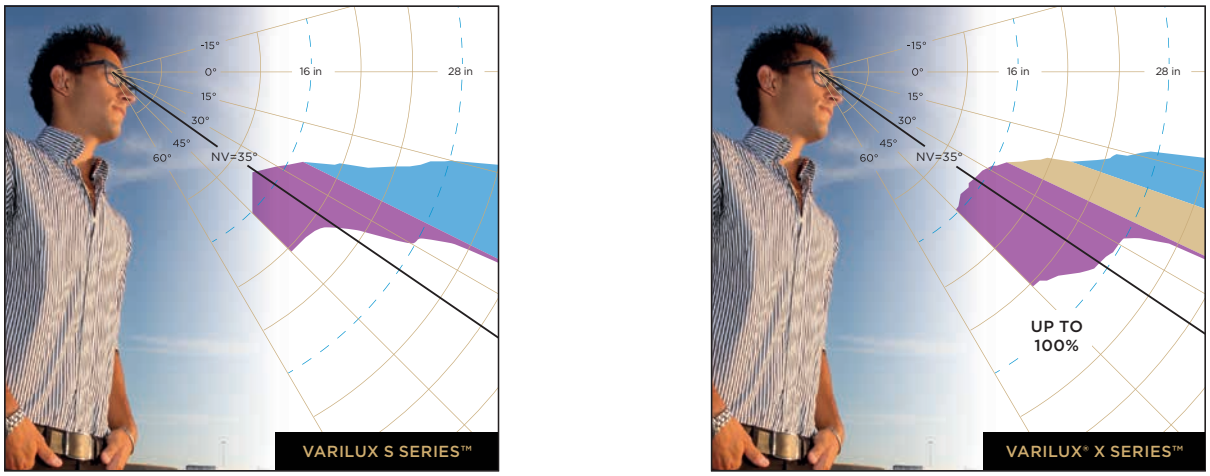
One way of testing the Varilux® X Series™ lens' performance is to calculate the amount of simultaneous vision a wearer needs in relation to the acuity threshold to be able to perform a visual task with a sufficient level of acuity.

As can be seen in the figures below, Xtend™ Technology improves the Varilux® X Series™ lens' performance markedly when the wearer is looking at a particular object.

FIGURES 7 & 8 clearly illustrate increases in both the depth and breadth of the near and intermediate vision zones.

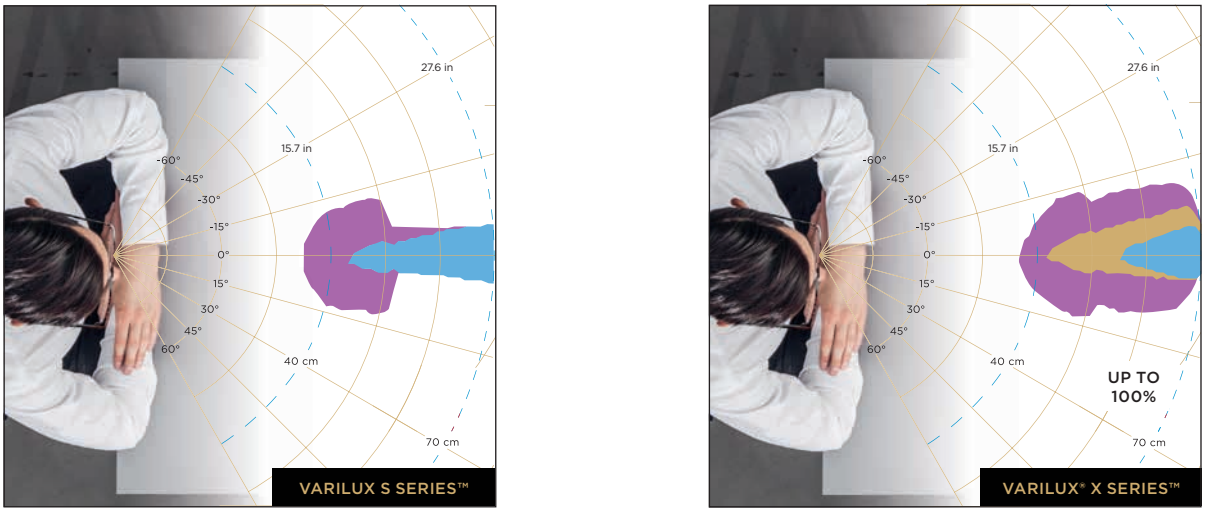
Specifically, Xtend™ Technology maintains a level of near vision acuity above the 0.15 LogMAR threshold, resulting in a longer range of vision and a larger area of sharp sight (**FIGURE 9**).

FIGURE 7. A SIMULTANEOUS VISION COMPARISON OF THE VARILUX S SERIES™ LENS & THE VARILUX® X SERIES™ LENS



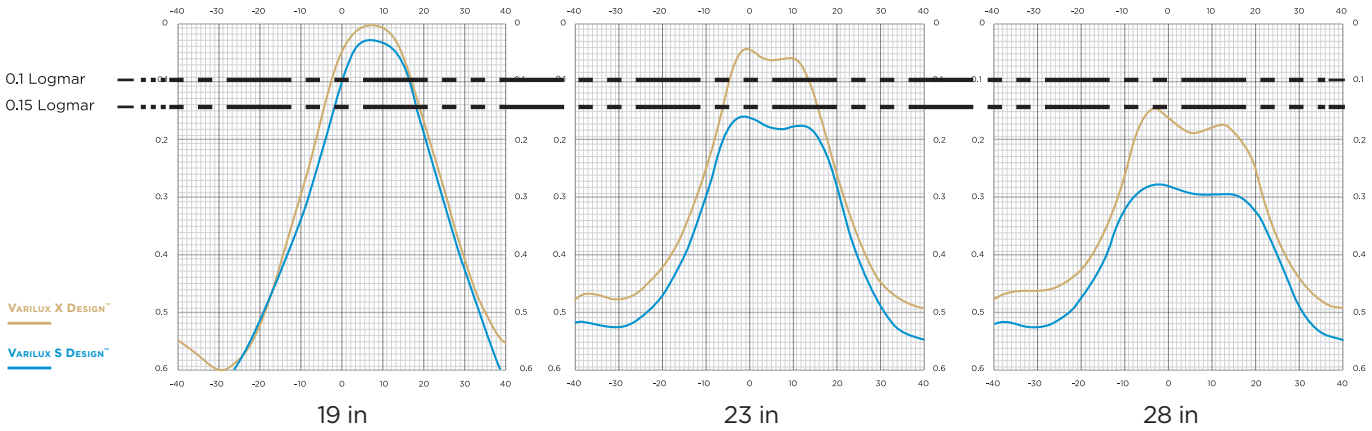
The performance of the Varilux S Series™ lenses (left) is compared to that of the Varilux® X Series™ lenses (right) for a wearer with a -3.00 sph lens with a +2.00 ADD. The purple zone represents near vision up to 20 inches, with an addition above 85%. The blue zone represents intermediate vision. The beige zone for the Varilux® X Series™ lens represents an addition from 60 to 85%.

FIGURE 8. THE SIMULTANEOUS VISION COMPARISON SEEN FROM ABOVE



Figures 7 and 8 illustrate the differences in performance for the same average wearer, characterized by an accommodation model.

FIGURE 9. ACUITY LOSS AS A FUNCTION OF HORIZONTAL FIELD OF VIEW FOR THREE DISTANCES



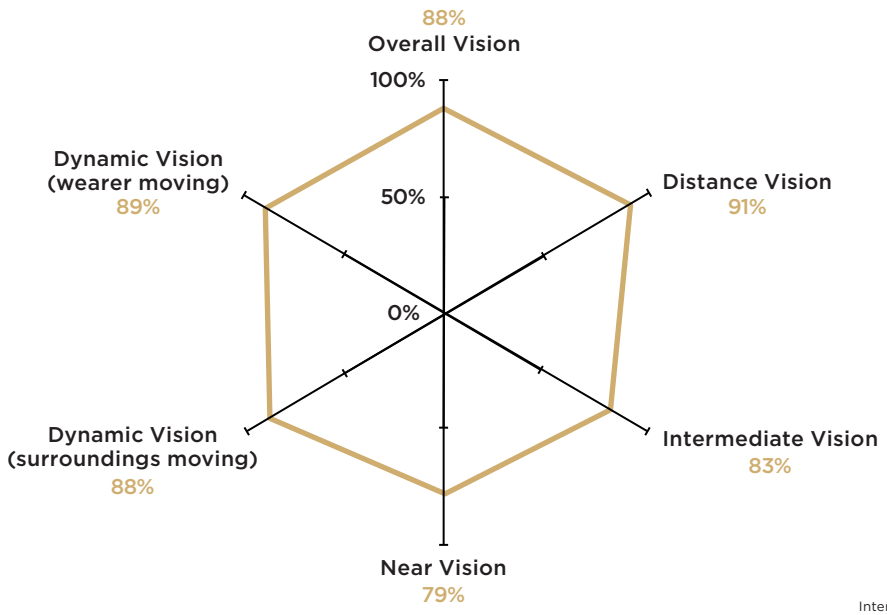
NB: The Varilux S Series™ lenses is compared to the Varilux® X Series™ lenses over three distances for a - 3.00D Addition 2.00 lens.

2. INTERNATIONAL LENS PERFORMANCE & WEARER TESTS

Essilor carried out two studies on Varilux® X Series™ lenses internationally. The first study looked at the overall performance of the lens. As can be seen from **FIGURE 10**, an overwhelming percentage of wearers enjoyed high-quality vision, whatever the distance, intermediate or near. For overall and dynamic vision wearers gave a rating on a 10-point scale from "not clear at all" to "very clear."

With respect to distance, intermediate and near vision wearers gave a rating using the same scale, plus a 10-point scale ranging from "very narrow" to "very wide"; for each distance, the average of the ratings from both scales was calculated to obtain a global visual quality criterion. In both cases 7 to 10 on the scales represented good visual quality.

FIGURE 10. PERCENTAGE OF WEARERS WITH GOOD VISUAL QUALITY WITH THE VARILUX® X DESIGN™ LENS



International multicenter study (n=66)

Wearers also rated their ease of adapting to the lens on a 10-point scale from "very difficult" to "very easy," with 7 to 10 considered the "easy" range. A full 82% of wearers experienced an easy adaptation.

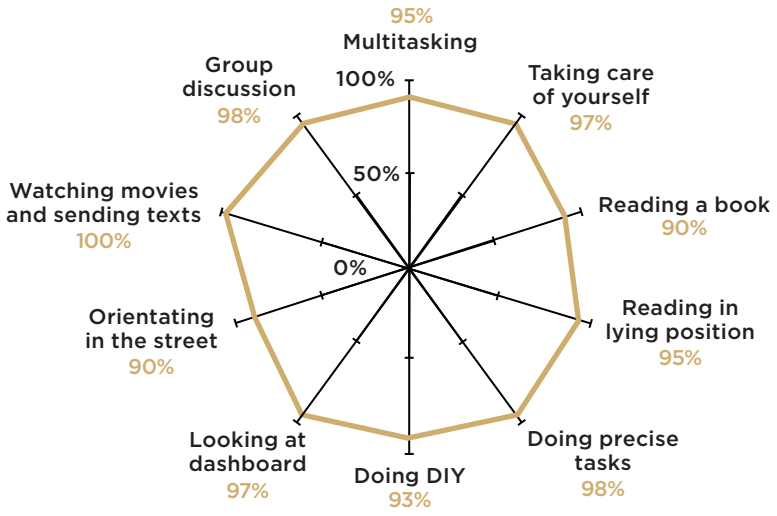
The second study, performed in France, **(FIGURE 11)** looked at the Varilux® X Series™ lens' key benefits, measuring how satisfied wearers were when carrying out activities within arm's reach. Again, they gave a score on a 10-point scale ranging from "not satisfied at all" to "very satisfied", with once again the 7 to 10 range being the overly positive one. The exception was "multitasking," where wearers rated "satisfaction with focus."

Wearers were also asked to rate their head movements needed to see clearly activities carried out at arm's length, choosing from "not at all", "a little," "just right," "too much" and "far too much". The percentage of wearers who needed minimal or no head movements to see clearly was 97% for horizontal vision and 93% for vertical vision.

Both studies then compared the Varilux® X Series™ lenses to Varilux S Series™ lenses. The international study found 65% of wearers had an overall preference for the Varilux® X Series™ lenses over the Varilux S Series™ lenses. In terms of visual quality, using the same scales and criteria, the former had markedly better performance (**FIGURE 12**). The ease of adapting to the lens was also higher for Varilux® X Series™ lenses (82% vs. 76%).

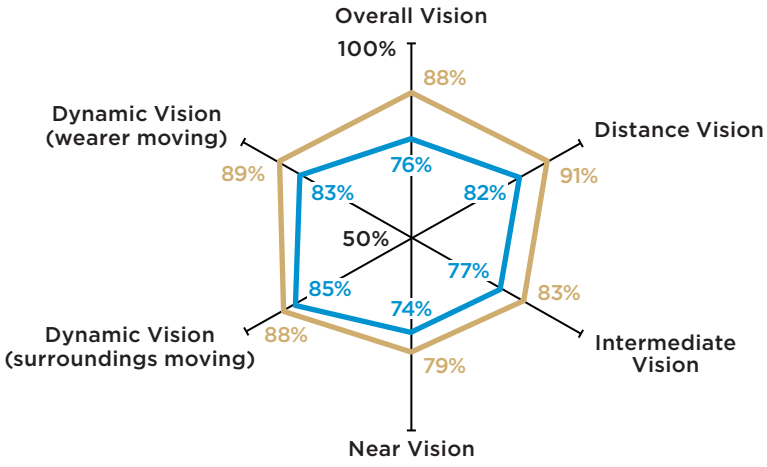
As for their preference for the Varilux® X Series™ lens when it came to multitasking within arm's reach, the French study found no less than 86% of wearers preferred the Varilux® X Series™ lenses over the Varilux S Series™ lenses. A similar preference was found when wearers were asked about which lens they preferred with respect to head movements needed for tasks performed within arm's reach: 74% chose the Varilux® X Series™ lenses over the Varilux S Series™ lenses.

FIGURE 11. SATISFACTION WITH ACTIVITIES WITHIN ARM'S REACH



Single-center study - France (n=42)

FIGURE 12. PERCENTAGE OF VARILUX® X SERIES™ LENSES & VARILUX S SERIES™ LENSES WEARERS WITH GOOD VISUAL QUALITY



International multicenter study (n=66)

Key Takeaways:

- Essilor has engineered the world's most advanced premium progressive lens, Varilux® X Series™, to optimize vision within arm's reach (between 16 and 28 inches).
- By developing an advanced calculator, Essilor is now able to manage more complex lens designs and generate acuity targets to optimize the performance of lenses.
- Drawing on its SynchronEyes™ and Nanoptix™ Technologies, Essilor has developed new Xtend™ Technology to greatly enhance the Varilux® X Series™ lenses' performance for visual tasks within arm's reach.
- Xtend™ Technology increases both the depth and breadth of the wearer's simultaneous vision for multiple near distances.
- International Essilor wearer studies evaluating the overall performance of the Varilux® X Series™ lenses revealed that an overwhelming percentage of wearers enjoyed high-quality vision, whatever the distance.
- Additionally, the international wearer study revealed that 95% of wearers were satisfied with the lens when multitasking within arm's reach. Wearers also found that they did not need to move their head horizontally (97%) or vertically (93%) to see clearly with the Varilux® X Series™ lens.
- Studies in the US showed wearers preferred Varilux® X Series™ lenses 3 to 1 over Varilux S Series lenses for reducing head movement required to find the "sweet spot."
- Finally, US wearer studies showed that more than 7 out of 10 wearers preferred Varilux® X Series™ lenses over Varilux S Series™ lenses.

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