Varilux® XR track

designed with the exclusive

Near Vision Behavior Measurement

White Paper

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Preface

Our near vision requirements have changed significantly over the last 20 years. We live in a digital age whereby digital platforms have really transformed the way in which we can access reading materials, such as e-readers, smartphones, tablets and laptops.

Reading is a key visual task in everyday living, which involves a complex coordination of eye movements, and adjustments to our head and posture.

To provide our presbyopic patients with the visual comfort for near vision, it is essential that the near vision zone in a progressive lens is optimally located at the very spot where the wearer directs their gaze and explores the lens during reading. If we know the wearer's posture and behavior while reading, it is possible to personalize the design of the progressive lens in accordance with the wearers needs.

To solve that problem, EssilorLuxottica's research teams developed a special vision task which can accurately reflect the wearer's reading posture. Near Vision Behavior (NVB) personalization, aims to ensure lenses are designed and tailored as closely as possible to the wearer's specific posture and behavior during near vision tasks.

Personalization can now be taken to the next level as the NVB measurement can be integrated with the Varilux® XR series™ lenses.

This paper will review the main aspects of the near vision behavior highlighting the benefits, measurements and the Varilux® XR track lenses specifically designed with the unique NVB measurement.

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Introduction

Near Vision Behavior (NVB) personalization aims to ensure lenses are designed and tailored as closely as possible to the wearer's specific posture and behavior during the near vision task. The process involves two phases: first, the individual's postural behavior must be measured and analyzed; second, a personalized lens design must be computed.

As the measurement must be representative of the wearer's typical near vision behavior, the task that is used to determine it and personalize the lenses constitutes perhaps the most common near vision activity: reading.

The Varilux® XR series™ lenses are the first eye-responsive progressive lens that respects the natural behavior of the eye and instant sharpness even in motion, powered by behavioral artificial intelligence using predictive modeling. Varilux® XR track lenses are the versions integrating NVB measurement which takes personalization of the lens to the next level including the actual behavioral data of the wearer in the predictive modeling. The near vision point is then positioned as a function of the actual behavior of the wearer providing a long-lasting comfort in close-up vision.

1. The visual needs of progressive lens wearers

Our near vision requirements have changed dramatically over the last 20 years. Today, modern lifestyles result in people's eyes moving 100,000 times a day to process all the visual information they are exposed to.[1] We live in an era of information overload that is increasingly on the go. Information navigates faster and push notifications are a part of our lives. We receive around 80 notifications per day[2]. We switch our attention and gaze back and forth between various tasks and from one object to another. To keep up with these dynamic visual needs, and high-speed processes, today's progressive lenses need to ensure we can perform accurate ocular navigation.

Even if progressive lens wearers are satisfied with their progressive lenses overall, they still have difficulties to find the right spot in the lenses for a near vision task.[3]

For many wearers of progressive lenses, the near vision zone might be an issue. This zone is not always found instinctively and immediately by the wearer causing difficulties in maintaining sharpness, especially when in mobility situations, such as checking notifications on a smartphone whilst walking down the street; or switching between screens (dashboard, GPS) and the road while commuting.

This discomfort forces the wearer to adapt their behavior subconsciously to maintain sharpness by taking a millisecond to adjust, slowing down or even stopping.

Therefore, it is crucial to provide a lens that is personalized to the wearer's exact natural behavior to meet the visual requirements in a highly complex environment.

2. Near Vision Behavior, a unique measurement

The physiology of reading

A significant part of our daily lives is taken up by the activity of reading. In effect, our eyes are constantly looking at letters and words, whether they be in books, magazines, advertisements or on screens found on laptops, smartphones and tablets. Nevertheless, it remains a recent activity when considered on the scale of human evolution.[4]

To read, our visual system requires specific movements. For example, when reading English text across a line and scanning the text from left to right a series of small saccades and fixations are required.

Moreover, it requires the reader to make use of their fovea, the central part of the retina which covers about 2° of visual angle and where we achieve the highest visual acuity.

To be able to read words, the reader must move their eyes sequentially to place the words on the fovea. They do so in small rapid jerky movements from one fixation to another. These saccades entail the eye changing direction repeatedly to fixate on different parts of the text to gather visual information.

For Western languages, most saccades are from left to right and top to bottom. However, about 10 to 15% of them run in the other direction, allowing the reader to reprocess elements of the text: these are known as regressive saccades[5].

The process of reading cannot generally be achieved by eye movements alone. The position of the head must be adjusted for the eye to be able to reach different targets and locations. Eye movements are thus normally supported by head movements[6].

Much of what we read, such as books, magazines or tablets, is handheld. The reader can modulate both the distance between the text and the eyes, and the relative angles between the head and the words. The interaction between eye movements, the posture of the head and the overall position of the body is expressed by the reading distance, the downward gaze and lateral offset.

While the base pattern for reading is the same among different individuals, there are differences in postural behavior. But, as Proudlock and Gottlob (2007) explain, though humans show a remarkable degree of flexibility in eye-head coordination strategies, individuals will often demonstrate stereotypical patterns of eye-head behavior for a given visual task[7].

Despite this, on an individual basis, as people have different arm lengths or even preferences in terms of reading behavior, there are differences in terms of reading distance, downward eye direction and dynamic aspects.[8] Therefore, there is also an interest in measuring each individual value to go beyond in the personalization of the lens design.

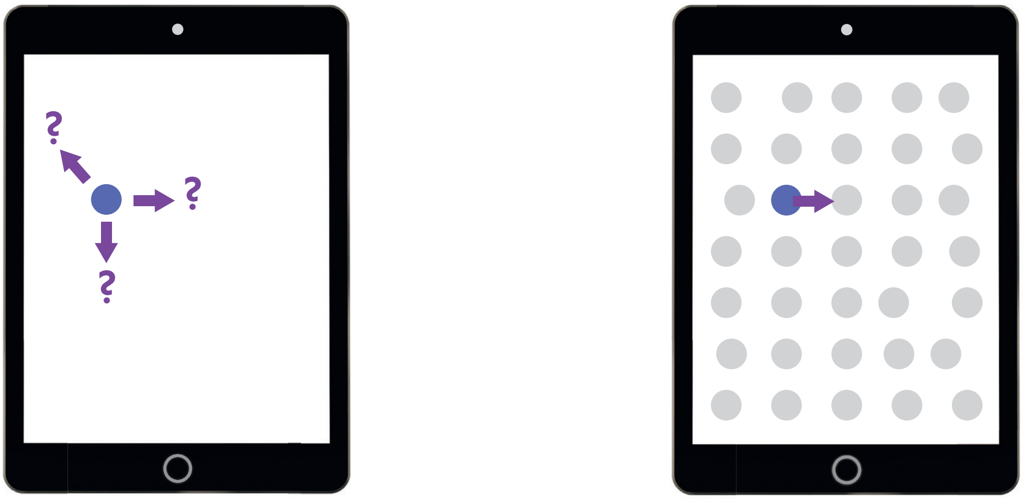
The use of text simulation

Knowing the postural behavior of a reader is unquestionably valuable in the context of progressive lens selection. The goal is to determine the individual's natural posture, i.e. the posture they would adopt if no optical correction were necessary. It follows, then, that measuring it can be problematic for the simple reason that to read most wearers need to use their optical correction. This gives rise to two problems: the correction may no longer be accurate, and the individual might be modifying their posture.[9]

To resolve this, EssilorLuxottica® has developed a method based on a task which can be carried out without corrected vision (it can be performed with myopia of less than -10 diopters or if hyperopia + addition is less than +7.50 diopters). It entails a large blue disc displayed on a tablet computer against a white background. As it moves around the screen, the subject must follow it with their gaze. This is referred to as reading simulation task.

The duration and position of a followed visual stimulus affects both head and eye coordination[10]. The shifting pattern of the disc is similar to an average reading pattern. Mean fixation durations and saccades were defined based on data obtained and compiled by Rayner (1998). In EssilorLuxottica®'s model the mean fixation of an adult reader is 233 ms and the mean saccade size is 6.3 characters long.

The duration of the reading simulation task is set to 17 or 18 seconds, depending on how long the fixations last. Moreover, its pattern is not the exact reproduction of the pattern of the reading eye's movement in so far as it does not contain backward saccades. This is to make the task as predictable as possible. The successive positions of the disc are always represented on the screen by a pattern of gray dots to guide the subject in their eye fixations and make the next target highly predictable **(Figure 1)**. This enables voluntary saccades just like in real reading[11], influencing head movements. Even if the task has been initially designed based on data obtained for English readers, the successive positions and durations of the disc could be modified to 16 other languages with different reading speeds and directions (e.g., reading from right to left, as in Arabic written languages).



The next position is unpredictable without dots

The grid of dots enables the reader to predict the landing position of his next saccade

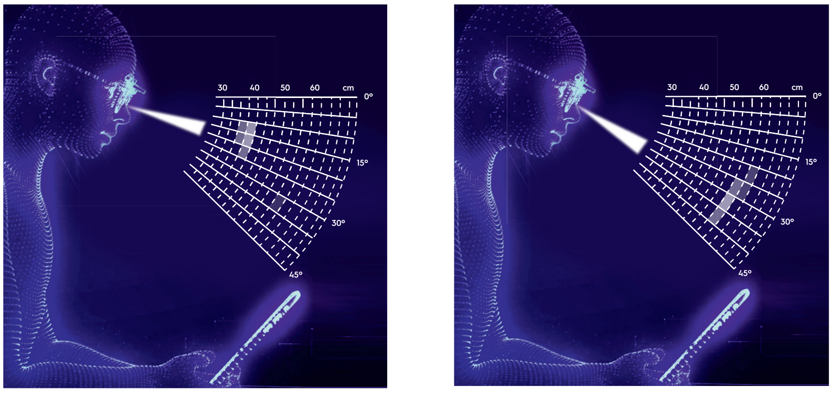
Figure 1. *Illustration of pattern of dots*

The NVB measurement criteria

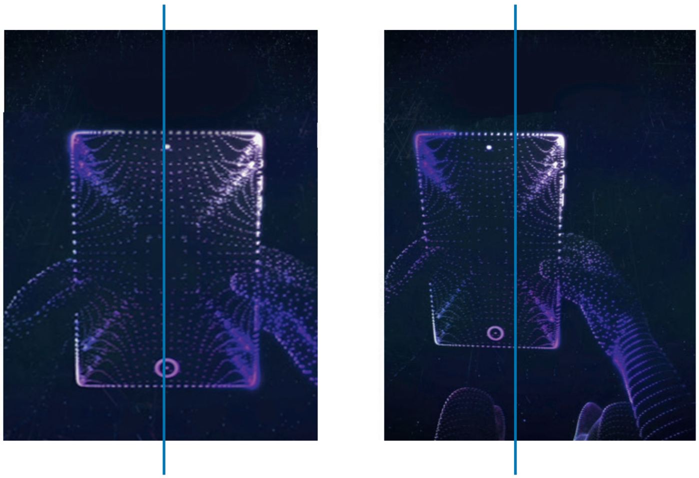
The NVB measurement aims to determine the parameters of the habitual near vision postural behavior of the reader. It does so by recording their eyes' centers of rotation while they perform the reading simulation task. More specifically, four distinct parameters are measured. Three are related to the wearer posture **(Figure 2):**

- Gaze lowering
- Lateral offset
- Reading distance

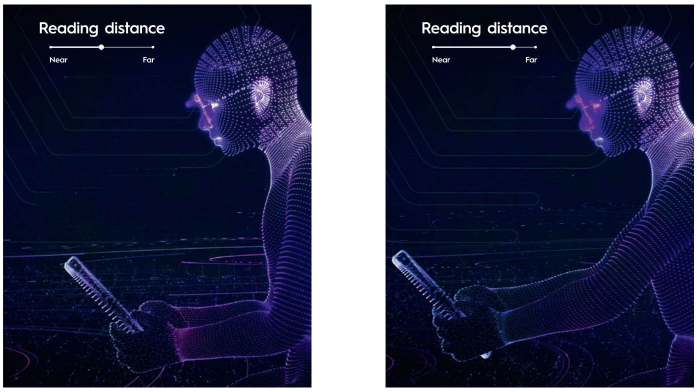
The NVB measurement records the way a wearer holds the tablet during the task, with the NVB posture component calculated as the mean posture throughout the reading simulation task.



Gaze lowering



Lateral offset



Reading distance

Figure 2. *Wearer posture parameters*

- The fourth parameter is the wearer's visual behavior

This represents how the wearer uses their gaze during the reading simulation task. Some wearers have a large tendency to move their eyes, lowering their gaze after each line returns; while some have a vertical static gaze throughout the entire reading simulation. **(Figure 3)**.

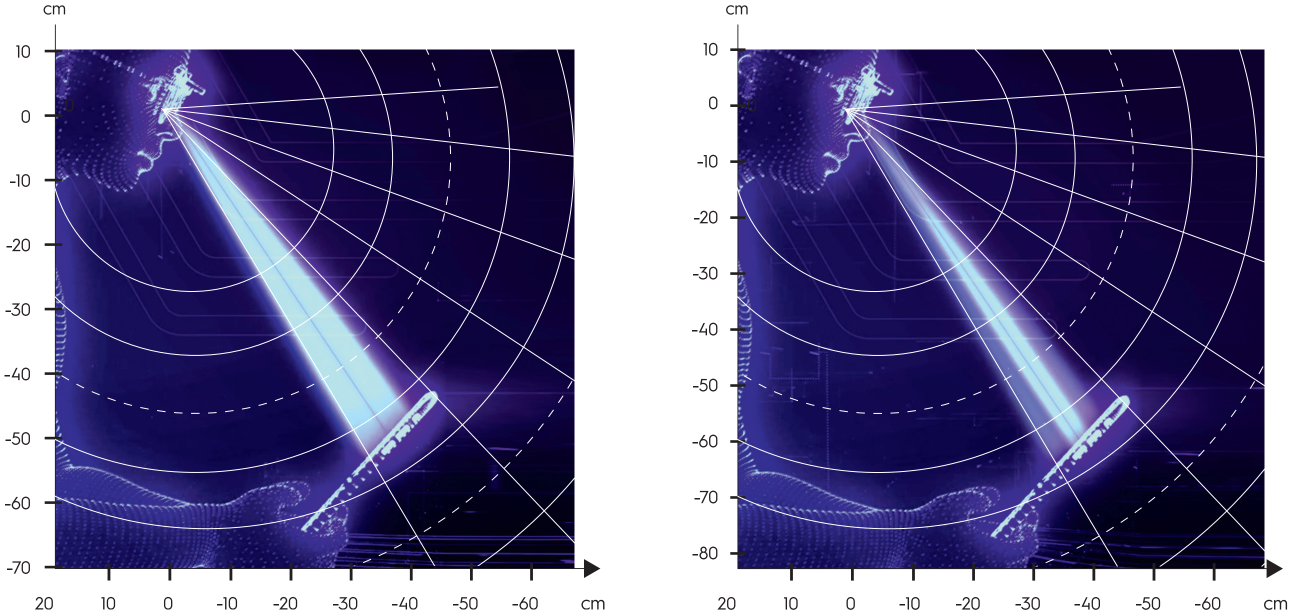


Figure 3. *The wearer visual behavior*

A tablet with an 8 to 10 inch screen to display the reading simulation and a frontal camera with more than 1 MP to record the head position is used to measure NVB. The wearer is equipped with a metrologic reference (also called a clip) on their frame. The camera records the clip position for each new stimulus position (blue dot). The tablet records the stimuli positions and the current positions of the wearer's head (thanks to the clip). This enables the system to evaluate and record the individual's gaze direction during the reading simulation task (**Figure 4**).

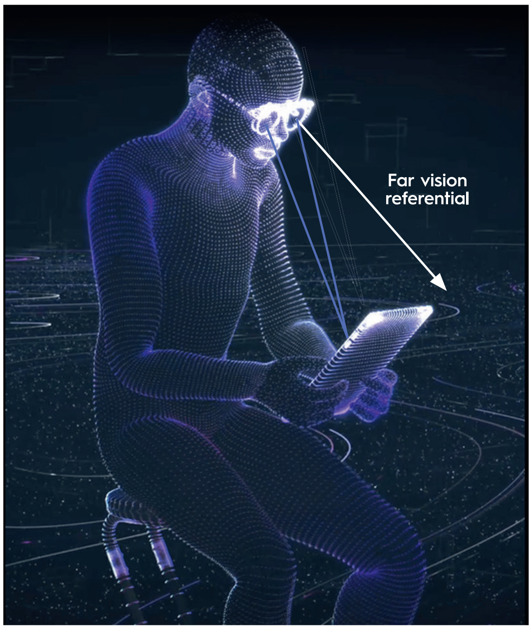


Figure 4. *Directions of gaze*

NB. The blue lines represent the directions of the gaze, determined thanks to the clip, which records head movements.

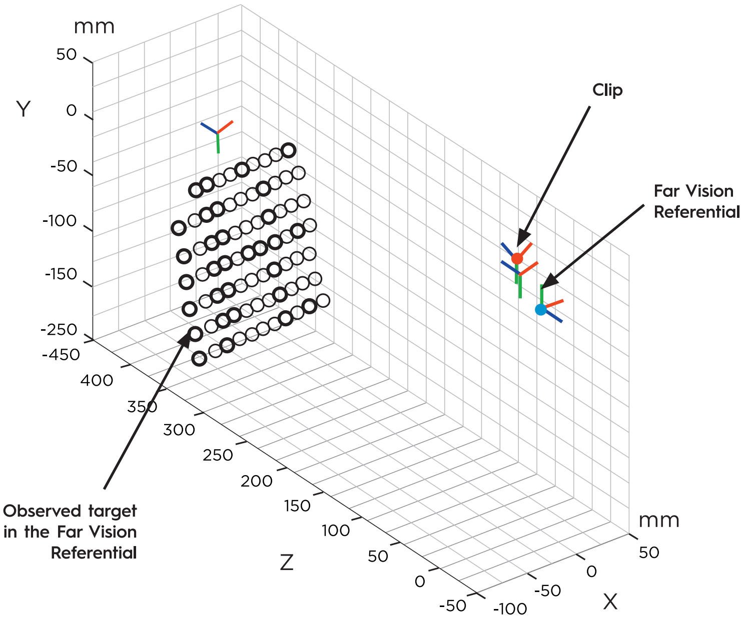


Figure 5. *Data expressed in the far vision referential*

Gaze directions are expressed in the far vision referential **(Figure 5)** in order to apply ray-tracing optimization when the lens is calculated.

The measurement procedure

The first step in the measurement is to obtain the wearer's far vision reference position to compute the downward gaze direction, allowing the 0° position to be defined. All angle values are then calculated from this.

The reference posture is obtained using the Eye-Ruler™ 2 procedure, with both front and three-quarter pictures. Following the measurement protocol, the wearer is asked to sit on a chair (it is recommended they keep the frame and clip on).

The NVB measurement is not recommended for myopia which is greater than -10 diopters or hyperopia + addition of more than +7.50 diopters. (except if the individual wears contact lenses).

A demonstration should be performed to allow the wearer to familiarize themselves with the task. The speed can be adjusted to the individual's liking.

A training test is carried out before the measurement to ensure the camera is functioning properly. This entails the wearer focusing on the blue dot at the center of the tablet **(Figure 6).** If the camera cannot be detected, there is a camera return to show they are not on the field of the camera. A message then asks the ECP to turn the tablet upside down to position the front camera on the bottom of the tablet. This new position allows specific posture detection.

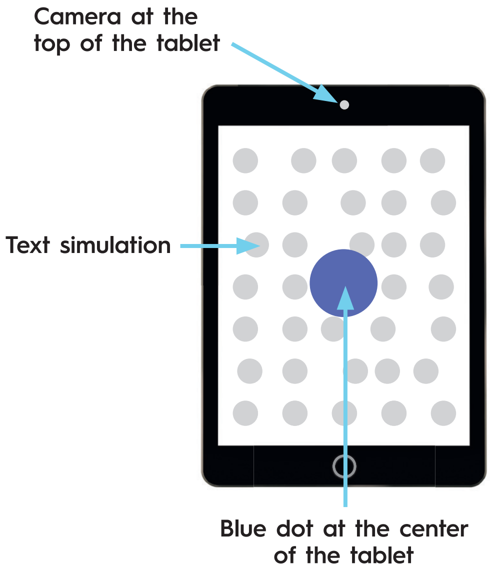


Figure 6. *Detection test*

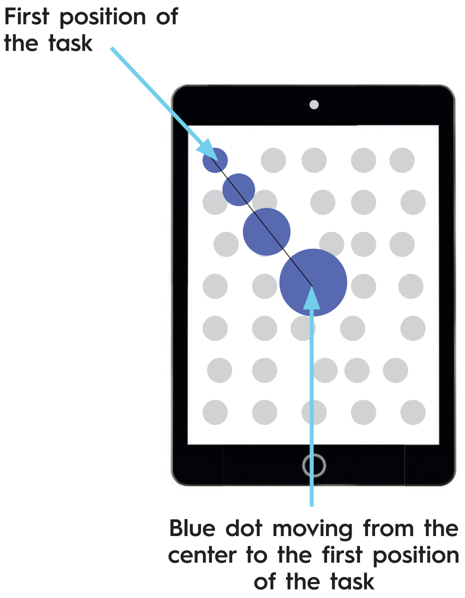


Figure 7. *Blue dot start position*

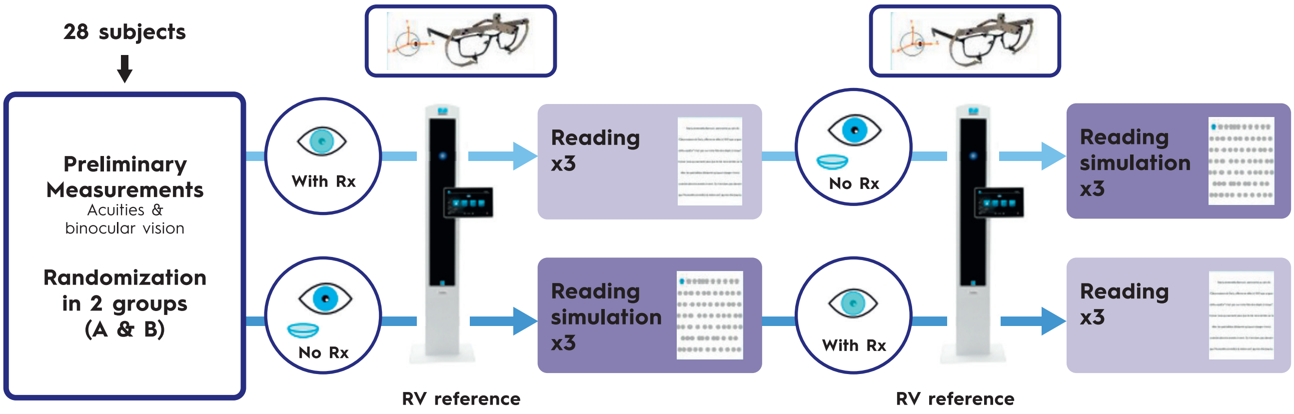
When clip detection is activated, the blue dot will move from the center to the first position on the reading simulation task **(Figure 7)**. The 3D position of the clip is continuously recorded thanks to the tablet's camera. The measurement stops when the final position is reached. The four parameters (gaze lowering, distance, lateral offset and visual behavior) are calculated only at the end of this measurement.

Validation

If the postural data obtained by the reading simulation can predict the postural parameters adopted by a wearer when reading for real, then the reading simulation task has been successful.

EssilorLuxottica set up an experiment[12] where the gaze lowering angles and reading distances of 28 ametropes and presbyopes were obtained and compared for two conditions: simulation of reading with no correction and normal reading with contact lenses. The order of the conditions was counter-balanced, and each measurement was repeated three times **(Figure 8).**

Method

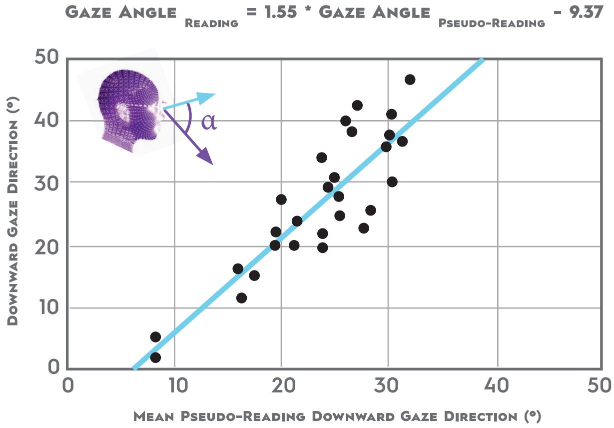


Contact lenses were used for visual correction in reading task to avoid postural change due to prismatic effects.

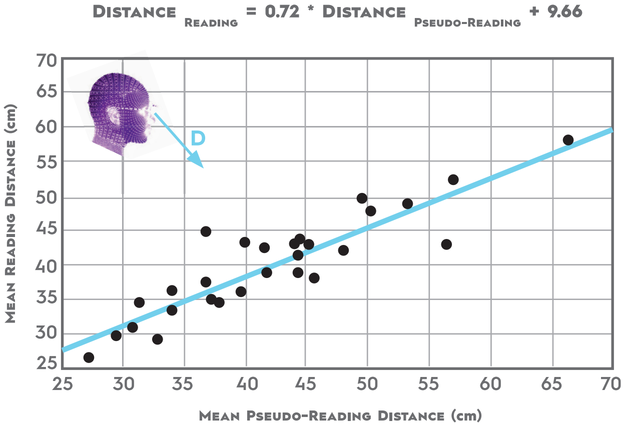
Two postural parameters were compared:

- **Mean downward gaze angle (α)**
- **Mean reading distance (D)**

Result



$\text{Gaze Angle}_{\text{Reading}} = 1.55 * \text{Gaze Angle}_{\text{Pseudo-Reading}} - 9.37$



$\text{Distance}_{\text{Reading}} = 0.72 * \text{Distance}_{\text{Pseudo-Reading}} + 9.66$

Mean values	Reading	Reading simulation
Downward gaze angle	27.0° ± 1.1	23.5° ± 6.3
NVB Output	40.0 cm ± 7.4	42.1 cm ± 9.2

Significant ($p<0.001$) linear regression for:

- Downard gaze directions R^2 = .764
- Distance R^2 = .807

Figure 8. *Validation method and result*

As can be seen in Figure 8, the data from reading and reading simulation strongly correlate, both for reading distances and downward gaze directions. Moreover, even if there is some divergence, the reading simulation values can be used to predict the posture the wearer would adopt in different situations. Despite the fact the wearer's vision is not corrected during measurement, the reading simulation task allows the ECP to infer the real near vision posture data.

3. Varilux® XR track: Lenses specifically designed with the unique NVB measurement

NVB is a measurement which enables the ECP to tailor the near vision position of the progressive lens design to the wearer's behavior during a near vision task and optimize the shape of the near vision zone. The output of this NVB measurement is an alphanumeric code which combines two aspects of the postural and visual behavior of the wearer:

- The NVB Point, representing the barycenter measurement results of near vision stimuli in the ERC referential
- The NVB Ratio, which denotes the measurement dispersion around the NVB point of the wearer's response to the stimuli

Based on an analysis done on more than 16,000 orders of Varilux® X series with NVB personalization option, it has been observed that the four parameters mentioned earlier such as gaze lowering expressed as vertical angle (α°), lateral offset expressed as horizontal angle (β°), reading distance (mm) and visual behavior expressed as NVB ratio vary from one person to another **(Figure 9).**

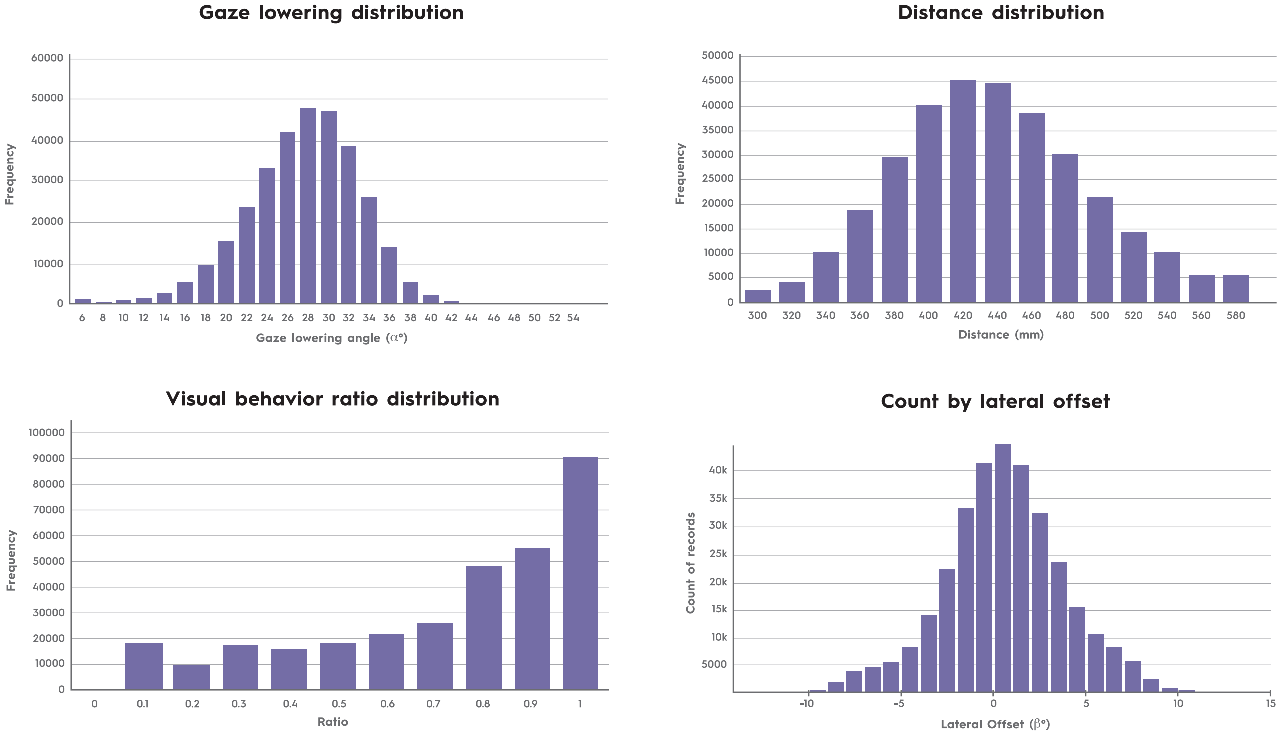


Figure 9. *Gaze lowering (α°), Reading distance (mm), Visual Behavior (ratio) and Lateral offset (β°) distributions*

Then the first step of the calculation is to decode the NVB output. As a result, the NVB point and the NVB ratio are obtained as input parameters for optimization.

NVB design optimization initially consists of making use of the physiological characteristics of the wearer (e.g. the interpupillary distance, the ERC and the prescription), the characteristics of the frame (e.g. the shape, size and position) and the characteristics of the future lens (e.g. the front surface, geometry and index). The data decoded from the NVB measurement in the visual space is also taken into account.

The next step is to optimize the position of the near vision zone of the lens by using ray tracing with the postural component of NVB. The idea is to achieve the best compromise between the near vision posture, as obtained from NVB measurement, and other visual performances. Indeed, modifying the progression length directly affects the fields of view in intermediate and near vision.

The third step is the progression profile optimization with respect to the NVB ratio for the behavioral component. The goal is to adjust the available vertical area in near vision and design the shape of the near vision zone. This can provide the wearer with dynamic eye movement in a larger zone.

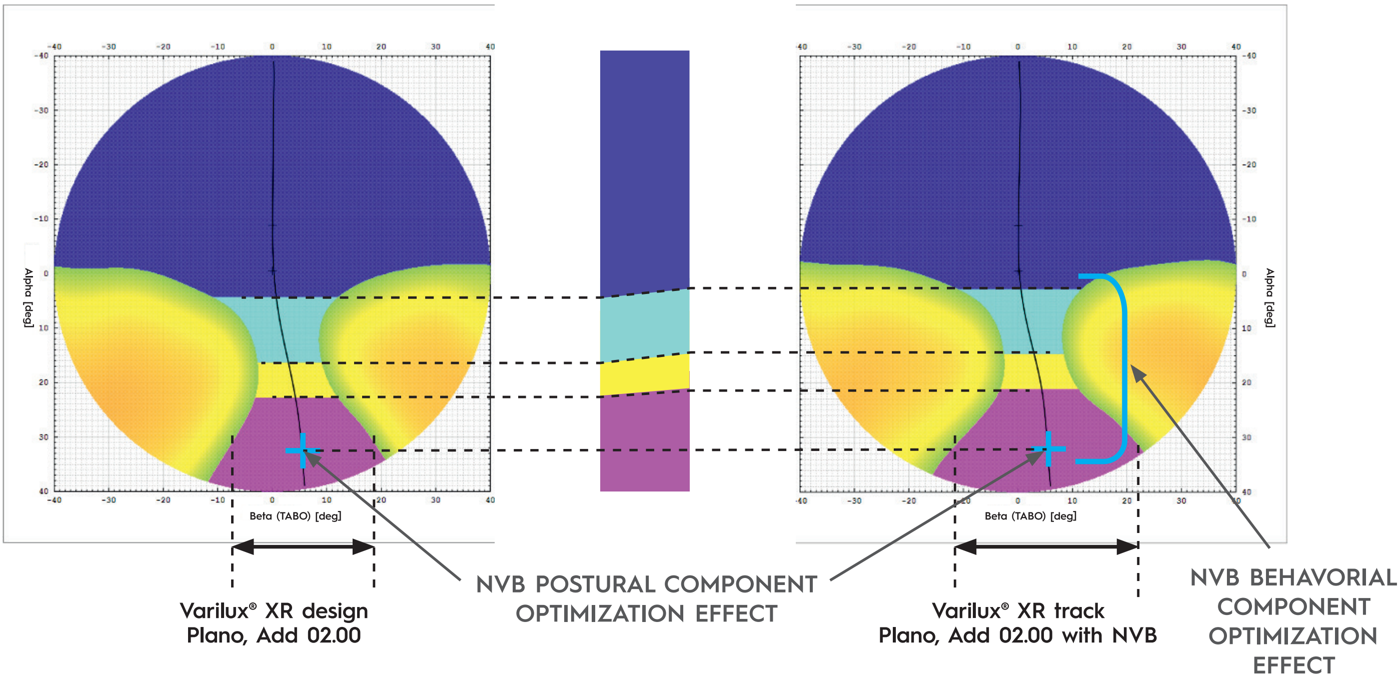


Figure 10. *NVB optimization on a lens*

The position of the near vision is a direct result of optimization. It is possible to measure the near vision point on the final lens and provide a progression length value and inset value. Compared to current personalization of progressive addition lenses, these values result from the NVB optimization and are not an input parameter as it is for a fit option.

While NVB in itself is a major breakthrough, if the near vision zone of the lens, derived from NVB optimization, is not within the limits of the frame its benefits will be annulled. This is the reason why securing the near vision zone within the frame is an essential part of NVB personalization option.

If the fitting height, frame size B and pupillary distance are used, the NVB calculation ensures 100% of the lens with near vision is secured in the frame based on available data from the order (on condition the fitting height and frame size are compatible with the minimum progression length available with the Varilux® XR series™ lenses).

The fourth step is the lateral offset that is taken into account to decide on the width of the near vision zone. The greater the lateral offset, the more the patient's eyes will deviate from the middle of the standard corridor position inside the lenses to its fringes, leading to a loss in comfort of vision To accommodate for this natural shift (i.e. lateral offset), the near vision zone through the lens should be wide enough for the wearer to see sharply when reading.

Figure 11 represents the transfer function defined to make the link between the measured lateral offset and the percentage of enlargement of the Near Vision zone.

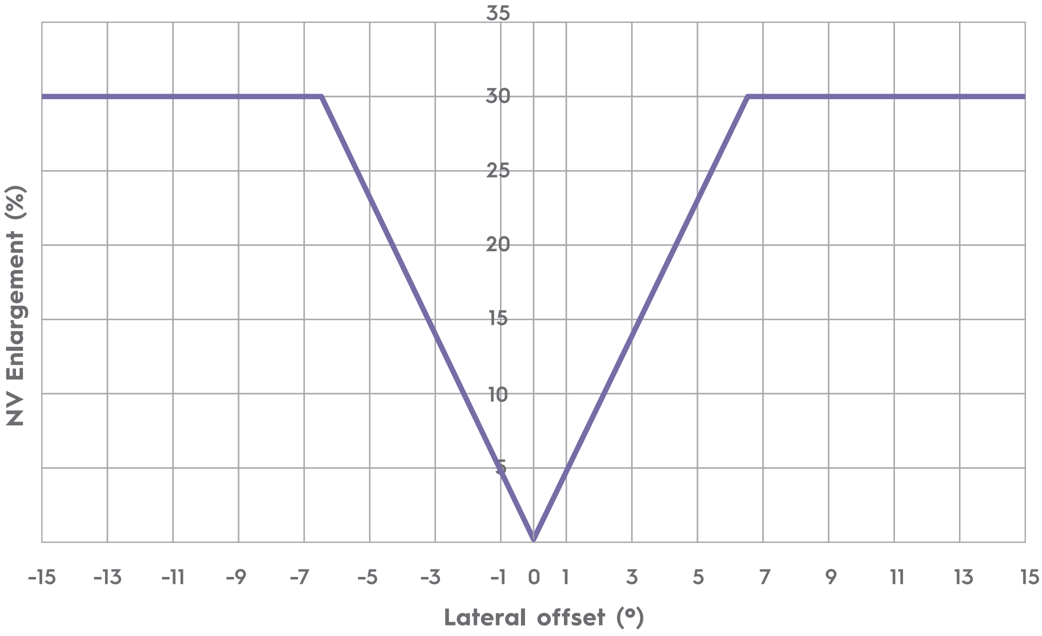


Figure 11. *Near vision enlargement (%) as a function of lateral offset (°)*

For a lateral offset equal to zero, the Near Vision zone of the lenses does not need to be enlarged as it corresponds to the standard visual behavior taken into account in design conception. In order not to modify the design too much, a maximum of +30% enlargement has been defined and associated with angle β° >6.5°. For intermediate lateral offset the proposed transfer function is proportional to the absolute value of angle β° (i.e., lβ°l).

4. Varilux® XR track wearer benefits

In addition to an accurate prescription, personalization of the complex surface of the progressive lens is needed to deliver full performance. Indeed, personalized data will ensure the most accurate design calculation.

Powered by behavioral artificial intelligence and individual measurements, Varilux® XR track lens upgrades the predictive visual behavior profile for a personalized one.

Beyond adjusting the position and vertical extent of the near vision zone, Varilux® XR track lens also extends the near vision width according to patient behavior.

A wearer test was conducted to assess the perceived performance of Varilux® XR track lens. Eurosyn, an independent institute, recruited a panel of 73 experienced PAL wearers, mostly wearing high-end progressive lenses. They were between 45 to 65 years old, with a recent pair of current eyeglasses and a valid prescription matching their current eyeglasses, but they didn't feel the need for an update of their vision correction. They have renewed their progressive lenses at least once. Prescriptions were as follows: myopes 23%, emmetropes 41%, and hyperopes 36%. It is demonstrated that 89% of the progressive lens wearers maintained sharp vision at near during a long task[13].

Furthermore, thanks to the NVB calculation exclusive to Varilux® XR series™ lenses, the near vision zone is widened according to the lateral offset. Varilux® XR track lens offers long-lasting comfort in close-up vision to the consumer thanks to an extended near vision zone up to 25% according to the patient's behavior[14].

5. Conclusion

Every patient is unique, as is the way they hold their devices or books and the way their head will then move in relation to the device or book while reading. When talking about reading with progressive lenses, each millimeter counts. The slightest variation in the way the patient holds their book or phone may have an impact on their comfort, as it will change the positions of the object targets.

The NVB measurement reproduces on a tablet screen, while the patient is still wearing the already adjusted frame with the dedicated clip placed on it, a reading simulation task, as if they were reading on a paper sheet.

By analyzing the real 3D position of the device relative to the patient's head during the measurement, we are able not only to reposition the near vision zone of the lens in order to have it provide the right power at the right spot for the patient, but also to vertically and horizontally enlarge the near vision zone according to the patient's visual behavior. Indeed, for a patient with a spread behavior, the zone will be larger, to allow them to move their eyes with ease.

NVB takes into consideration the different near vision parameters: gaze lowering, reading distance, visual behavior and lateral offset, to adapt the near vision zone positioning and the near vision zone vertical and horizontal enlargement.

From a lens design perspective, the design calculation will include individual measurements in its modeling. Basically, the visual behavior profile is now personalized and not predicted. Wearers may therefore benefit from a binocular near vision zone positioned with a higher level of matching to their behavior.

Thanks to the NVB calculation exclusive for Varilux® XR series™ lenses, the near vision zone is widened according to the lateral offset. Varilux® XR track lens offers long-lasting comfort in close-up vision thanks to an extended near vision zone up to 25% according to the patient's behavior.

Moreover, a wearer test was conducted to assess the perceived performance of Varilux® XR track lens. It demonstrated that the majority of the progressive lens wearers maintained sharp vision at near during a long task.

References

1. Peter H. Schiller, Edward J. Tehovnik, Neural mechanisms underlying target selection with saccadic eye movements, Progress in Brain Research, Elsevier, Volume 149, 2005, Pages 157-171

2. Acer, Utku & Mashhadi, Afra & Forlivesi, Claudio & Kawsar, Fahim. (2015). Energy Efficient Scheduling for Mobile Push Notifications. EAI Endorsed Transactions on Energy Web

3. Varilux® XR series™ Consumer Expectations and Behaviors with Progressive Lenses - IPSOS - BR/FR/ IT/UK/US – Q1 2022 (n=4062 progressive lenses wearers)

4. Dehaene, S. (2009), Reading in the brain: The new science of how we read, Penguin.

5. Rayner, K. (1998), Eye movements in reading and information processing: 20 years of research, Psychological Bulletin, 124, 372-422.

6. Kowler, E. et al. (1992), Coordination of head and eyes during the performance of natural (and unnatural) visual tasks, The head-neck sensory motor system, 419-426.

7. Proudlock, F. A. & Gottlob, I. (2007), Physiology and pathology of eye-head coordination, Progress in retinal and eye research, 26, 486-515.

8. Paillé, D., Perrin, J.-L., & Debieuvre, A. (2015), New postural behaviors related to the use of digital devices involve new characteristics for occupational lenses, Investigative Ophthalmology & Visual Science, 56, 4304.

9. Han, Y. et al. (2003), Static aspects of eye and head movements during reading in a simulated computer-based environment with single-vision and progressive lenses, Investigative Ophthalmology & Visual Science, 44, 145-153.

10. Oommen, B. S., Smith, R. M., & Stahl, J. S. (2004), The influence of future gaze orientation upon eye-head coupling during saccades, Experimental brain research, 155, 9-18.

11. Walker, R. et al. (2000), Control of voluntary andreflexive saccades, Experimental brain research, 130, 540-544.

12. Poulain, I., Pérrin, J.-L., & Escalier, G (2016), A tool for measuring reading posture with no need for visual correction, Optom Vis Sci, 93: E-abstract 165190.

13. Essilor – Varilux® XR series™ - in-life consumer study – Eurosyn – 2022 – France (n=73 progressive lens wearers; 65/73).

14. Internal R&D simulations – 2022 – according to patient behavior

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