

# Varilux S 4D, binocular personalization based on the sighting dominant eye

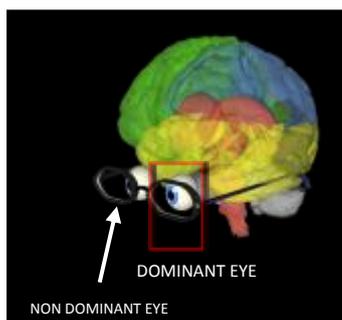
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Seeing with two eyes confers many advantages compared with seeing with one eye: a wider field of view, a better performance in terms of visual detection or discrimination, a better 3D perception and better perception of position of objects in space.

Binocular capability of the visual system is based on fine analysis by the brain of both image similarities and image differences. Seeing the world through two eyes produces a triple mechanism: simultaneous vision, fusion which occurs when the images are similar enough and stereoscopic sense due to the analysis of small differences between the two images.

Binocular performance is also known to be superior to the one achieved through monocular conditions; this is the phenomenon of binocular summation when visual detection or discrimination with 2 eyes over-performs that of the best eye. Another factor, the ocular dominance is also of premium importance in driving the dynamics of the two eyes.

For the first time in the ophthalmic industry, a binocular personalization of a progressive lens is based on the sighting dominant eye leading to totally new design and unsurpassed performance, giving access to the 4<sup>th</sup> dimension of visual benefits: improved reaction time for an unlimited Reflex Vision.



At the top of Varilux S series range, Varilux S 4D protected by 13 patents or pending patents, includes 3 exclusive technologies.



## 1- Binocular Vision and progressive lenses, state of the art

For more than 40 years, designers have made considerable efforts to improve binocular vision with progressive lenses. This includes asymmetrical designs to allow as much as possible sensory fusion whatever the gaze direction [1], [2], and a non linear path of progression profile to follow the path of natural convergence.

Despite all these innovations, one main limitation didn't allow these improvements to deliver their total benefit: The fact that each lens was optimized without knowing the specificities of the other.

With current technology each lens is calculated individually according to their unique prescriptions. As a result, the right and left lenses could have different designs, the resulting images on the retina don't match, and that may induce

difficulties to be fused by the brain. (figure 1). The wearer perceives narrower binocular field of vision.

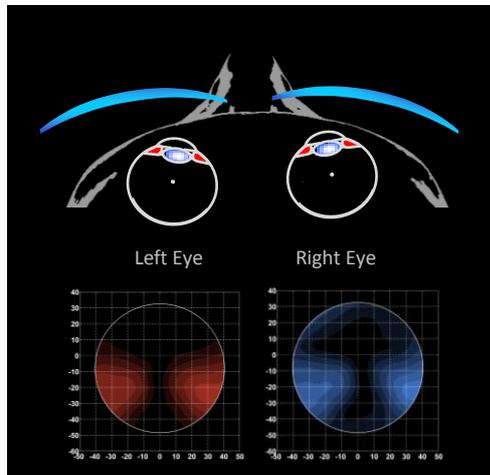


Figure 1: Monocular conception of Pal leading to binocular field of vision restriction

## 2- Personalization and progressive lenses

With new Digital Surfacing technology and dual side designs, it has been possible for some time to take advantage of lens personalization. Lenses are tailored according wearers' individual specificities measured through individual data, including frame data, individual eye characteristics or behavioural measures depending on each wearer. By taking into account such specificities, wearers benefit from improved sharpness and global visual comfort.

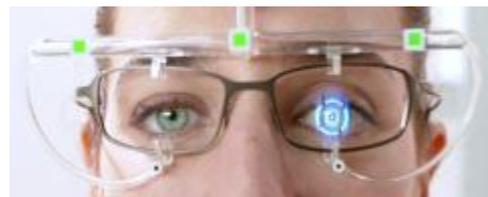
Spectacular progress in imaging devices, materialized through Visoffice® and Eye Code® technologies, enables us to reach an unsurpassed level of personalization that benefits presbyopes. By measuring the precise positioning of the eye rotation centre, which is very specific for each individual eye, it is now possible to deliver the exact power value needed by the wearer and to exactly locate the areas on the lens which are used for a given gaze direction.

Further to these specificities, Varilux S 4D also includes a new measurement

exclusive to Visioffice®: the sighting dominant eye.

## 3- The sighting dominant eye

What does it mean to have a sighting dominant eye? Like handedness, having a sighting dominant eye is a pledge of efficiency. According to Porac and Coren [3], eye dominance is relatively immutable. It is the tendency to prefer the visual input from one eye to the input from the other eye. This preference can be expressed in several terms: higher image clarity or salience, greater eye stabilization, higher reaction time etc., implying that dominant eye is more sensitive than the other and/or that information from the dominant eye may be processed more rapidly (Schoen and Scofield [5], [7]).



The first reference to any form of lateral dominance was done in 1593 when Porta discussed the existence of a dominant eye in his book *De Refractione*.

In 1973, Coren and Kaplan [6] demonstrated three types of ocular dominance: sighting dominance, sensory dominance and acuity dominance. The first one represents performance in a number of visual tasks in which the input of one eye is suppressed to allow unambiguous, non diplopic information to reach the higher visual centers. It is linked with the motor components of the visual system. The second, sensory dominance, defines which input is preferred when the perceived information is sustained and discrepant. The third one, acuity dominance, results in the pre-eminence of the better performing eye, if any.

Even if many studies lead to different interpretations (mostly due to the fact

that the results are highly dependant on tests used to make the measurements), it is now recognised that the sighting dominant eye is the more robust and very well correlated with the motor control of eye movements.

### **Measuring the Sighting Dominant eye**

At the present time, over 235 papers have been published that incorporate measures of ocular dominance [3]. Schematically, 3 types of tests have been described: Sighting tests, the ones for which a monocular selection is forced, Unconscious sighting tests, the more robust and the one which is now part of the Visioffice® and a third category based on Binocular rivalry.



Figure 2 : Measurement of sighting dominant eye with Visioffice® and 4D tablet

Over the years a number of studies have explored sighting dominance using large population samples, showing very good consistency (Porac et Cohen [4] for a review). Approximately 65% of all observers sight with the right eye, 32% have a left dominant eye and the remaining 3% show no consistent preference.

Sighting dominance is a consistent and pervasive phenomenon, this behaviour being relatively independent of chronological age or cultural differences.

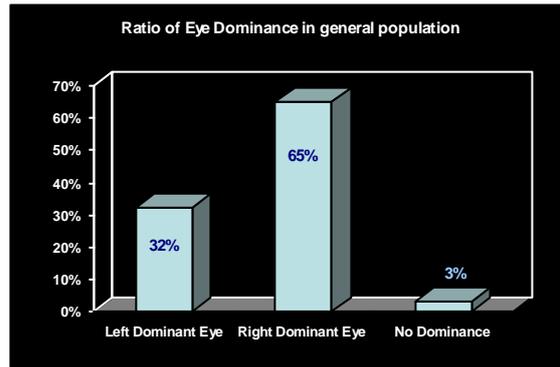


Figure 3 : Ration of Eye dominance in general population

### **Sighting dominant eye in visual processes**

In two recently published papers, Shneur and Hochstein [5], [7] expressed that the dominant eye has priority in visual processing, perhaps including inhibition of non-dominant eye representations.

- The sighting dominant eye is leading from a motor point of view and reaches the target more quickly. This phenomenon has been shown by Kawata and Ohtsuka (2001) [8] : they measured the eye vergence movements in response to a visual stimulus placed in the middle of the 2 eyes and moving between 50cm and 20cm in distance in front of the subject. Their results suggest that the neural control system of convergence command preferentially the sighting dominant eye during the initiatory movement phase. The sighting dominant eye starts its vergence movement to the target more rapidly. It therefore reaches the target more quickly.

- The sighting dominant eye is not only leading in term of motor component of vision. Some inputs coming from the sighting dominant eye are also preferentially processed in comparison to the same inputs from the non sighting dominant eye: the target is better detected with the sighting dominant eye [7]. This means that some inputs coming from the sighting dominant eye are preferentially processed in comparison to the same inputs from the non sighting

dominant eye. This priority implies that the attention system may be activated differently by the two eyes. The brain seems to pay more attention to the inputs from the sighting dominant eye. Roth and al. [9] share the same conclusion.

- The sighting dominant eye is the directional guide for the other eye. It is involved in the perception of the binocular visual direction, and affects our estimation of object location in space [10].

**Role of the sighting dominant eye with progressive lenses**

In order to prove the specific role of the sighting dominant eye when wearing progressive lenses, we conducted exclusive experiments quantifying the impact of optical aberrations on reaction time during a dynamic visual detection task. When optical aberrations are present in front of the sighting dominant eye, reaction time of the wearer increases [11]. It is therefore even more important to take it into account in the calculation of the lenses.

This role of the sighting dominant eye has been demonstrated through a virtual reality experiment. This experiment has been conducted among several subjects: half with right sighting dominant eye, and half with left sighting dominant eye. For 4 series of 50 successive Snellen « E » targets differing by their orientation, each subject had to fix a central cross, then perform a saccade to the off-centered « E » target and indicate the orientation with a joypad. Both control and test conditions were applied: in control conditions, a symmetrical blur was applied on both eyes; in test conditions, an additional 0.75D monocular blur over control conditions was applied randomly on sighting and non sighting dominant eye.

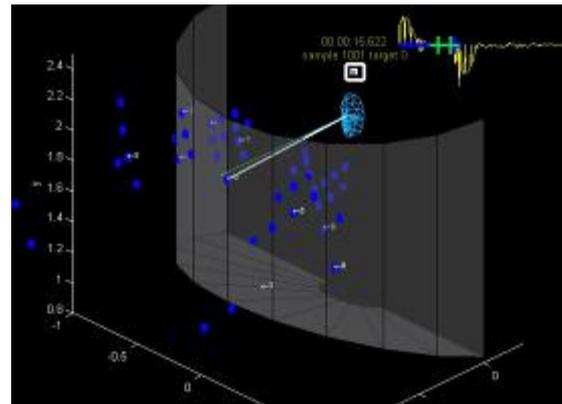
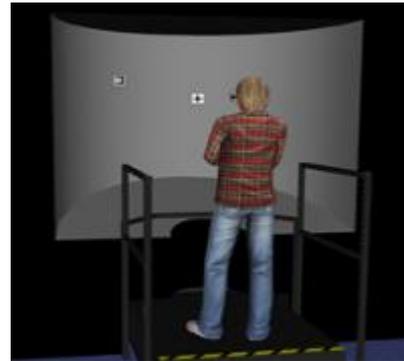


Figure 4 : Essilor virtual lens simulator experiment

Results show that reaction time is found to be significantly longer when the additional blur is on the sighting dominant eye ( $p < 0.05$ ).

Moreover the response time variation compared to control conditions is significantly non-null for the sighting dominant eye (95% confidence interval) whereas it isn't for the other eye.

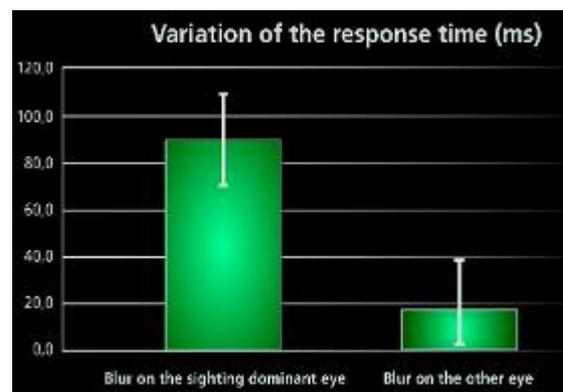


Figure 5 : Results of Essilor R&D virtual lens simulator experiment

#### 4- Exclusive 4D technology

A unique binocular conception is at the heart of Varilux S4D. Binocular vision is based on brain analysis of images received from each eye and the different roles played by each eye.

- Right and left images should be optically similar to enhance binocular summation for optimal visual performance. This is the aim of Synchroneyes technology [12].

- The sighting dominant eye should be favoured as it plays a leading role in driving the entire motor function of vision, and is particularly important in dynamic vision.

The calculation process of Varilux S4D considers both eyes as a pair but gives priority to the Dominant eye.

The sighting dominant eye is the driver of the most appropriate design, personalised to deliver the best vision. After 50 years of progressive lens innovation it is well known that certain design patterns give better performance to certain categories of wearers (Head movers prefer low distortion, Myopes prefer very sharp images ...).

Having identified the importance of the dominant eye in binocular behaviour, Varilux S4D is personalised taking into account the specific characteristics of this dominant eye, resulting in a unique design for the wearer.

The personalisation starts with the characteristics of the Dominant Eye, including:

- Distance prescription
- Astigmatism value and axis
- Addition value
- Monocular PD
- Eyecode parameters.....

From this the optimal design pattern is identified for this wearer. With Synchroneyes technology this design pattern is used in generating both lenses to ensure perfect fusion of images and optimized performance in a unique lens design (figure 6).

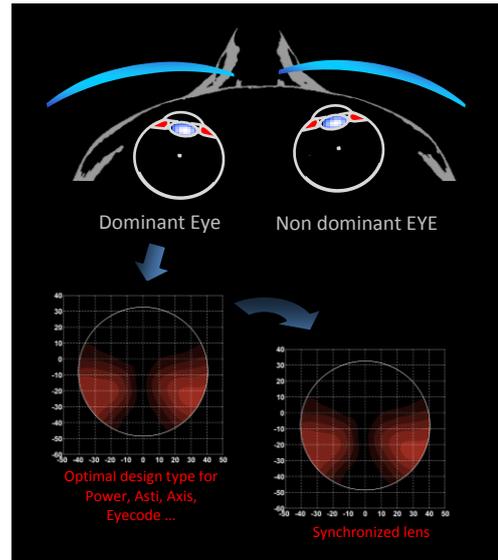


Figure 6 : 4D Technology calculation

- Step 1: measurement of the wearer personalized parameters to build a binocular system (cyclopean eye, environment, coordinate system,...).
- Step 2: definition of a binocular optical design to target taking the sighting dominant eye leading role into account.
- Step 3: applying binocular optical targeted design to both eyes thanks to the simultaneous optimization of the right and left lenses.

This multi steps process leads to a pair of totally new and innovative designs. This binocular personalisation, respecting the leading role of the dominant eye, ensures not only the widest fields of binocular vision, but also fluid transitioning between zones and responsiveness of vision is maximised. For the wearer: Wide Angle Vision, Autofocus and Reflex Vision.

#### 5 - Varilux S 4D, overall performances

4D Technology prioritizes the sighting dominant eye in order to preserve its role while SynchronEyes maintains good vision for the 2 eyes at all distances. By associating SynchronEyes and 4D Technology, the eyes-lenses system maximizes binocular performance.

As a very sophisticated product, a progressive lens is a sensitive product. The full assessment of the performance of a design can only be obtained when it is correctly positioned in front of the eye of the patient. Exactness and precise work of the eye care professional is the only way to guarantee completely successful adaptation. For this reason, the progressive lens is the ideal product for a full cooperation between prescribers, manufacturers and professionals who make the fitting.

For the first generations of progressive lenses, measuring distance PD and pupil height was sufficient, but the increasing

number of personalization parameters requires more precise and sophisticated measuring devices like Visiooffice®.

Wearer's appreciation and return rate for failure to adapt are important indicators for evaluating the performance of the global process, from prescription to fitting. Recent studies in different European countries have shown that the ratio of fully satisfied progressive lens wearers raised from 39% to 70% between standard service delivery to the most sophisticated product prescribed and delivered by highly qualified professionals with last generation measuring devices.

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