ARTIFICIAL INTELLIGENCE IN OPHTHALMIC LENSES PROJECT AND REALIZATION

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CON IL CONTRIBUTO NON CONDIZIONANTE DI SHAMIR

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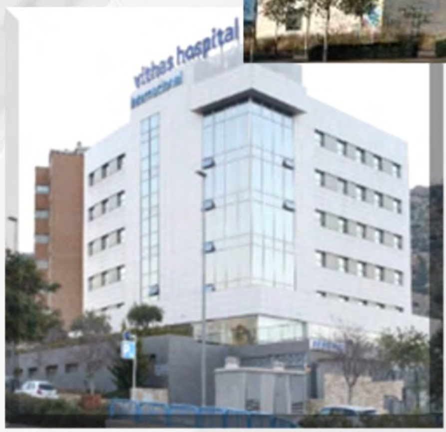
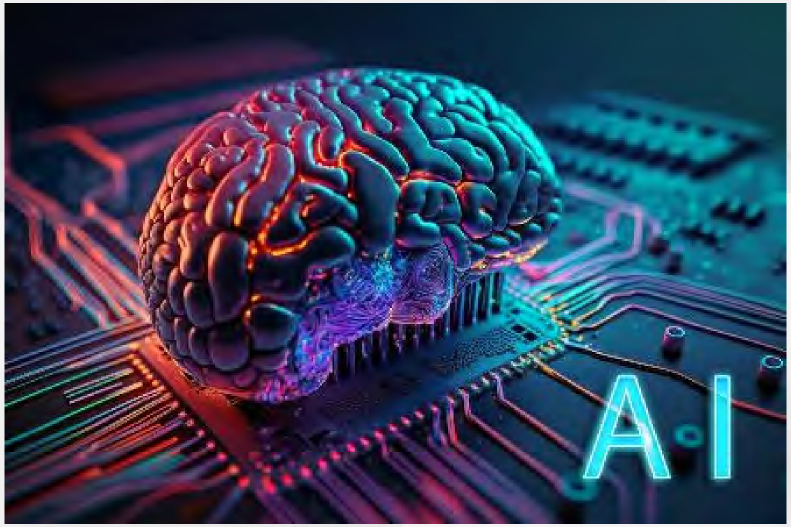


WHAT IS ARTIFICIAL INTELLIGENCE?

ARTIFICIAL INTELLIGENCE (AI)

- AI: field combining computer science and robust datasets to enable problem-solving
- Sub-fields: machine learning and deep learning:
  - Comprised of AI algorithms to create expert systems making predictions or classifications based on input data



ARTIFICIAL INTELLIGENCE (AI)

- Capabilities that researchers expect an intelligent system to display and cover the scope of AI research:

  - Reasoning, problem-solving
  - Knowledge representation
  - Planning and decision making
  - Learning
  - Natural language processing
  - Perception
  - Social and general intelligence*

ARTIFICIAL INTELLIGENCE (AI)

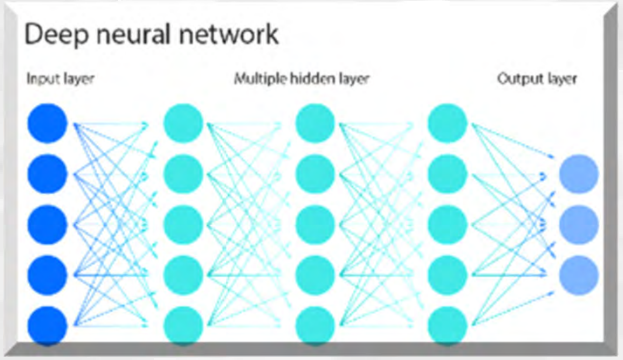
- Types:

  - Weak AI, Narrow AI or Artificial Narrow Intelligence RISTRETTA (ANI): AI trained and focused to perform specific tasks. It enables some very robust applications, such as Apple's Siri, Amazon's Alexa, IBM watson, and autonomous vehicles

  - Strong AI: made up of Artificial General Intelligence (AGI) and Artificial Super Intelligence (ASI)
    - AGI (general AI): theoretical form of AI where a machine would have an intelligence equaled to humans; it would have a self-aware consciousness that has the ability to solve problems, learn, and plan for the future
    - ASI (superintelligence): would surpass the intelligence and ability of the human brain. While strong AI is still entirely theoretical with no practical examples in use today

ARTIFICIAL INTELLIGENCE (AI)

- Types:



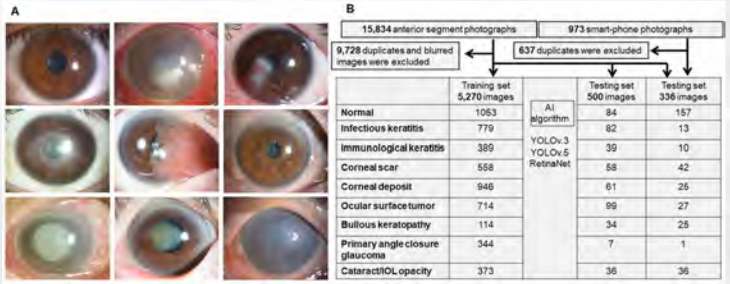
- Deep learning (DL): neural networks comprised of more than three layers can be considered a deep learning algorithm.

- DL and machine learning (ML) differ is in how each algorithm learns:
  - DL automates much of the feature extraction piece of the process, eliminating some of the manual human intervention required and enabling the use of larger data sets
  - Classical, or "non-deep", machine learning is more dependent on human intervention to learn. Human experts determine the hierarchy of features to understand the differences between data inputs, usually requiring more structured data to learn
  - "Deep" machine learning can leverage labeled datasets DATI ETICHETTATI (supervised learning) to inform its algorithm, but it doesn’t necessarily require a labeled dataset

ARTIFICIAL INTELLIGENCE (AI)

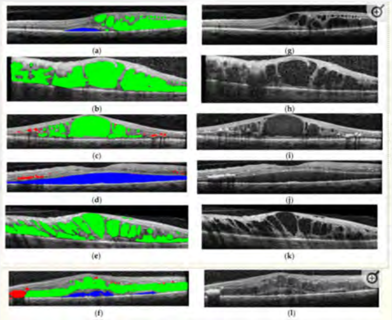
- Applications:
  - Speech recognition: uses natural language processing to process human speech into a written format
  - Customer service: Online virtual agents replacing human agents along the customer journey. They answer frequently asked questions (FAQs)
  - Computer vision: enables computers and systems to derive meaningful information from digital images, videos and other visual inputs, and based on those inputs, it can take action
  - Recommendation engines: using past consumption behavior data, AI algorithms can help to discover data trends that can be used to develop more effective cross-selling strategies
  - Automated stock trading: Designed to optimize stock portfolios, AI-driven high-frequency trading platforms make thousands or even millions of trades per day without human intervention

ARTIFICIAL INTELLIGENCE (AI)



	Training set 5,270 images	Testing set 500 images	Testing set 336 images
Normal	1053	84	157
Infectious keratitis	779	82	13
Immunological keratitis	389	39	10
Corneal scar	558	58	42
Corneal deposit	946	61	25
Ocular surface tumor	714	99	27
Bullous keratopathy	114	34	25
Primary angle closure glaucoma	344	7	1
Cataract/IOL opacity	373	36	36

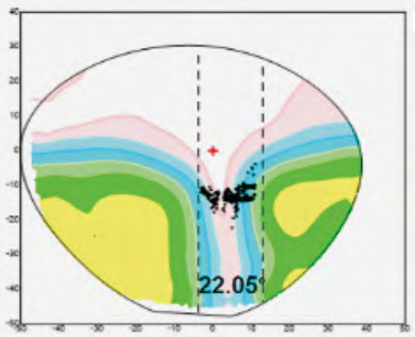
- Several applications in vision science:
  - Diabetic retinopathy screening
  - IOL LENTI INTRAOCULARI power calculation
  - Analysis of retinography
  - Chat GPT for providing information of ophthalmic diseases
  - Keratoconus detection
  - Contact lens fitting
  - Prediction of myopia progression with and without myopia control treatment
  - What about ophthalmic lenses???



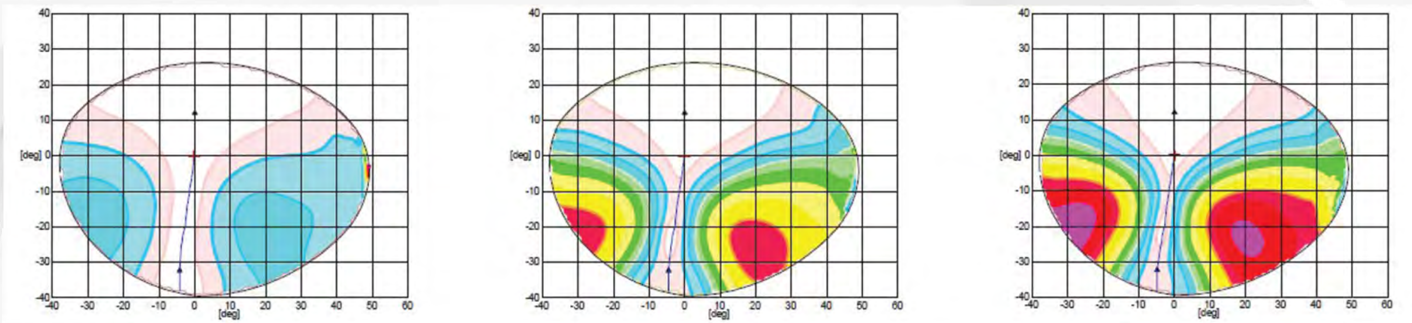
ARTIFICIAL INTELLIGENCE (AI)

- What about ophthalmic lenses???

- Could AI be useful for customizing them and obtaining more predictive outcomes???



CUSTOMIZATION OF OPHTHALMIC LENSES



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CUSTOMIZATION OPTHALMIC LENSES

- Ophthalmic lenses have reached high levels of customization:
  - Ocular parameters
  - Frames
  - Lifestyle

- However, not always the lenses are well tolerated, especially in case of PALs

CUSTOMIZATION OPTHALMIC LENSES

> Appl Opt. 2008 Dec 1;47(34):6434-41. doi: 10.1364/ao.47.006434.

Measurement and comparison of the optical performance of an ophthalmic lens based on a Hartmann-Shack wavefront sensor in real viewing conditions

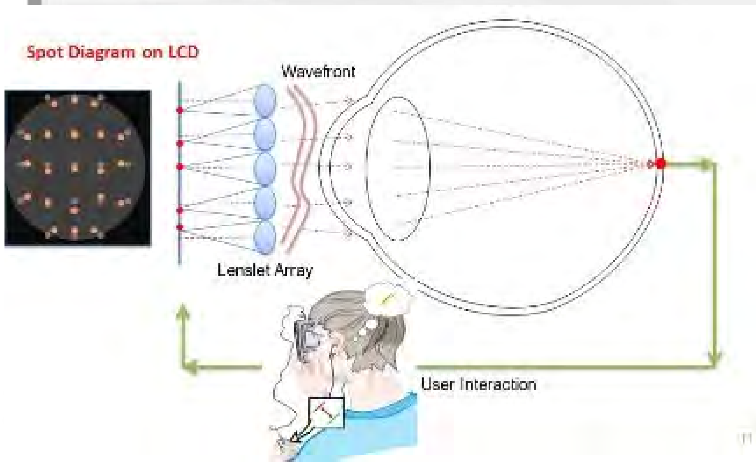
Chuanqing Zhou [1], Weichao Wang, Kun Yang, Xinyu Chai, Qiushi Ren

Affiliations + expand

PMID: 19037372 DOI: 10.1364/ao.47.006434

Abstract

The spatially resolved wavefront aberrations of four types of ophthalmic lens are measured with a custom-built apparatus based on a Hartmann-Shack wavefront sensor and specially designed positioning stage. The wavefront aberrations of the progressive addition lenses (PALs) are compared. The results show that the distribution depends much on the design philosophy, although the average values of root mean square in the entire measurement areas have no significant difference. It is feasible to evaluate the optical performance through the wavefront analysis of PALs, but how to meet the customized visual needs of patients and how to minimize the unwanted aberrations in some special zones are important points that should be taken into account.



CUSTOMIZATION OPTHALMIC LENSES

1040-5488/11/8802-0234/0 VOL. 88, NO. 2, PP. 234–243
OPTOMETRY AND VISION SCIENCE

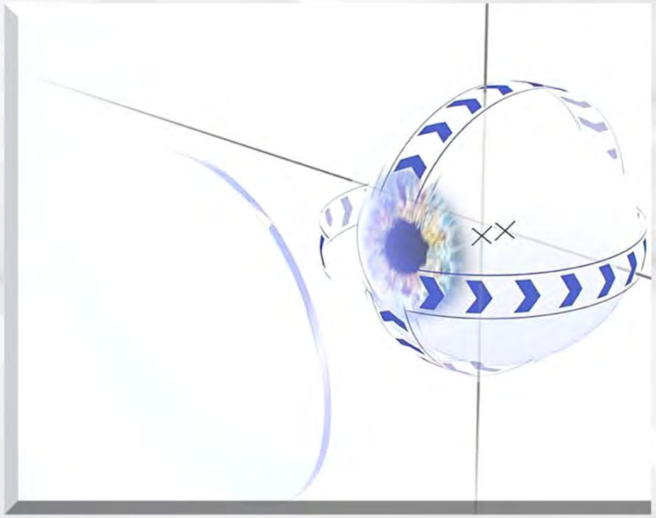
ORIGINAL ARTICLE

Clinical Assessment of a Customized Free-Form Progressive Add Lens Spectacle

Susan C. Han*, Andrew D. Graham†, and Meng C. Lin‡

ABSTRACT
Purpose. To determine whether there are significant differences in standard clinical measures of vision, progressive addition lens (PAL)-specific vision tests, or subjective ratings and preferences between customized free-form and standard non-free-form PALs in an experienced wearing population. In addition, we aim to determine whether subjective or objective clinical outcomes depend on demographic, PAL usage, spectacle prescription, or frame fitting characteristics.
Methods. In a randomized, double-masked cross-over trial, 95 experienced wearers wore Zeiss Individual customized free-form PAL spectacles (test) and standard non-free-form PAL spectacles (control) for 1 week each. At dispensing and after 1 week of wear, subjects were tested for distance and near visual acuity under both high and low contrast; in addition, 30° off-axis visual acuity was measured using a novel apparatus, as was the horizontal extent of clear, undistorted vision at reading distance. Subjects also completed a set of questionnaires detailing their satisfaction levels, adaptation times, and preferences for test or control spectacles for different visual tasks.
Results. The test spectacles were preferred overall and for distance, midrange, transitional and active vision, and rated higher in overall satisfaction ($p = 0.006$). There were no clinically important differences between test and control spectacles in standard clinical vision assessments. In the PAL-specific assessments, however, the horizontal extent of clear vision at reading distance was significantly greater with the test spectacles ($p = 0.004$).
Conclusions. There were statistically significant preferences for the optically customized free-form lenses over the non-free-form lenses. Subjects also reported a wider field of undistorted vision when looking through the reading zone of the test spectacles. Although standard clinical vision assessments are not sufficiently refined to detect important objective differences between the spectacle types, customization taking into account back vertex distance, segment height, pantoscopic tilt, and wrap angle can result in a superior subjective wearing experience for many PAL patients.
(Optom Vis Sci 2011;88:234–243)

Key Words: progressive addition lenses, customized free-form, presbyopia, bifocals, subjective assessment, visual performance, visual acuity, Amsler grid



	At fitting			After 1 week of wear		
	Control Mean (SD)	Test Mean (SD)	p	Control Mean (SD)	Test Mean (SD)	p
Distance VA, HC, off-axis left	0.10 (0.12)	0.10 (0.12)	0.802	0.10 (0.13)	0.10 (0.14)	0.861
Distance VA, HC, off-axis right	0.06 (0.11)	0.06 (0.11)	0.805	0.05 (0.09)	0.04 (0.10)	0.120
Distance VA, LC, off-axis left	0.24 (0.10)	0.24 (0.11)	0.663	0.24 (0.12)	0.24 (0.12)	0.816
Distance VA, LC, off-axis right	0.19 (0.11)	0.19 (0.12)	0.986	0.19 (0.10)	0.16 (0.11)	**0.002**
Near vision horizontal extent (cm)	20.03 (11.02)	19.19 (11.16)	0.264	17.74 (9.87)	20.06 (11.89)	**0.004**

At-fitting tests were taken immediately after dispensing. Control and test measurements were compared in this Table by paired t test. Distance VA off-axis (right side) under low contrast was significantly different between spectacle types; however, with a mean difference of 0.03 logMAR (~1 letter on the chart), the difference was not of clinical importance. The horizontal extent of clear vision at reading distance was significantly wider with the test lenses after 1 week of wear.

HC, high contrast; LC, low contrast.

CUSTOMIZATION OPTHALMIC LENSES

1040-5488/17/9402-0208/0 VOL. 94, NO. 2, PP. 208–218
OPTOMETRY AND VISION SCIENCE

ORIGINAL ARTICLE

Personalized Progressive Addition Lenses: Correlation between Performance and Design

Johanne Forkel*, Jenny Lorén Reiniger*, Adam Muschielok†, Andrea Welk*, Anne Seidemann†, and Peter Baumbach†

ABSTRACT

Purpose. A continuous set of personalized designs (design space) for progressive addition lenses (PALs) is investigated. The main goals are (1) to study how the subjects' perception of a personalized design depends on its position in the design space and (2) to compare the performance of personalized PALs to a conventional PAL with a fixed design.

Methods. In a double-blind study, 51 subjects compared Rodenstock Impression FreeSign 3, which is a family of PALs with a continuously controllable personalized design, and Rodenstock Progressiv Life Free, which is a conventional PAL with a single fixed design. The positions and sizes of viewing zones and the softness of gradients of mean power and astigmatism of personalized lenses were customized to individual viewing preferences. These designs were represented as points in a design space comprising a continuum of PAL designs. Subjective ratings and experimental measurements were used to study viewing zone widths, blur gradient smoothness, amount of distortion, the feeling of safety during motion, and overall wearing comfort.

Results. (1) Far viewing zone width (experiments and ratings), near viewing zone width (experiments), blur gradient smoothness, and the amount of distortion (ratings) were significantly dependent on the position of the personalized lens design in the design space. This was consistent with the structure of the design space. (2) 82% of the subjects chose personalized lenses as their favorite. Most subjects reported higher wearing comfort and tolerability with personalized lenses than with conventional lenses.

Conclusions. The designs of the tested personalized lenses were perceived by the subjects as intended. This is a prerequisite to the successful customization of PALs to individual wearing preferences. Possible reasons for the preference of the tested personalized lenses are the optimization with respect to individual wearing conditions and the personalization.

(Optom Vis Sci 2017;94:208–218)

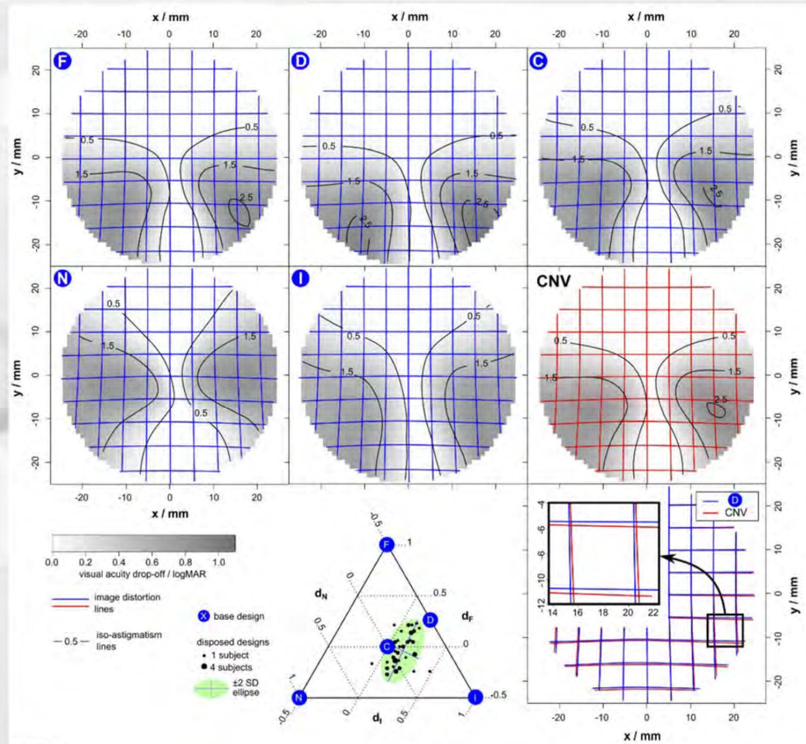
Key Words: progressive addition lenses, personalized PAL, lens design space, viewing zone size, wearing comfort

TABLE 2.

Base design properties and design characteristic: qualitative properties (rows) of the base designs (columns) underlying the design space

Base design	Central (C)	Far (F)	Intermediate (I)	Near (N)	Dynamic (D)
Expanded viewing zone	None	Far	Intermediate	Near	Far
Diminished viewing zone	None	Near	Far, near	Far	Near
Astigmatism gradients	Intermediate	Hard	Soft	Hard	Soft
Power increase	Intermediate	Fast	Slow	Fast	Slow
Stabilized near viewing zone	Yes	Yes	Almost	Yes	Almost
Design characteristic (d_F, d_I, d_N)	(0, 0, 0)	(1, −0.5, −0.5)	(−0.5, 1, 0)	(−0.5, −0.5, 1)	(0.25, 0.25, -0.5)

The position in the design space is determined by the design characteristic consisting of the design characteristic components far (d_F), intermediate (d_I), and near (d_N).



CUSTOMIZATION OPTHALMIC LENSES

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TABLE 3.
Summary of subject ratings by lens design

Design aspect in different viewing zones (VZs)	Absolute scale° Q_{25} PER	Q_{25} CNV	Q_{50} PER	Q_{50} CNV	Q_{75} PER	Q_{75} CNV	Sign test	Comparative scale* Q_{25}	Q_{50}	Q_{75}	Sign test	Design variation DC component	Rank correlation ρ (*P* value)
Viewing zone widths													
Far VZ	AAA	AAA	AAA	AA	AA	A	***0.007***	PER+	PER	N	***<0.0001***	d_F	0.31 (***.029***)
Intermediate VZ	AAA	AAA	AA	AA	A	A	0.087	PER	N	N	***0.016***	d_I	−0.03 (.82)
Near VZ	AAA	AA	AA	AA	A	A	0.051	PER	N	N	***0.022***	d_N	−0.16 (.25)
Blur gradient smoothness far VZ	AAA	AAA	AAA	AA	AA	A	***0.016***	PER+	N	N	***0.004***	d_N	−0.36 (***.0096***)
Absence of distortions													
Far VZ	AAA	AAA	AAA	AAA	AA	AA	0.069	N	N	N	0.069	d_N	−0.34 (***.02***)
Intermediate VZ (initial interview)	AAA	AAA	AA	AA	A	A	***0.022***	PER+	N	N	***0.012***	d_N	−0.61 (<***10^{-5}***)
Intermediate VZ (final interview)	AAA	AAA	AA	AA	A	A	0.034	PER	N	N	0.042	d_N	−0.25 (.08)
Near VZ	AAA	AAA	AAA	AAA	AA	AA	0.079	N	N	N	0.069	d_N	−0.16 (.25)
General comfort													
Initial interview	AAA	AAA	AAA	AA	AA	A	***0.009***	PER+	PER	N	***0.016***	d_N	−0.25 (.08)
Final interview	AAA	AAA	AAA	AA	AA	AA	***0.003***	PER+	PER	N	***<0.0001***	d_N	−0.15 (.31)

The 25%, 50%, and 75% quantiles (Q_{25}, Q_{50}, Q_{75}) of the absolute and comparative subject ratings of different aspects of the personalized (PER) and conventional (CNV) lenses are shown independently of the design characteristic (columns "absolute" and "comparative scale"). The design variation of the comparative ratings with the design characteristic (DC) components far (d_F), intermediate (d_I), and near (d_N) is shown as Spearman's rank correlation ρ. Significant ($P < .05$) *P* values are printed italic and bold.

°Absolute rating scale without neutral category:
AAA/AA/A/R/RR/RRR: I completely agree/I agree/I tend to agree/I tend to refuse/I refuse/I completely refuse.

*Comparative rating scale with a neutral category (N): PER++/PER+/PER/N/CNV/CNV+/CNV++: PER is much better/PER is better/PER is rather better/there is no difference/CNV is rather better/CNV is better/CNV is much better.

CUSTOMIZATION OPTHALMIC LENSES

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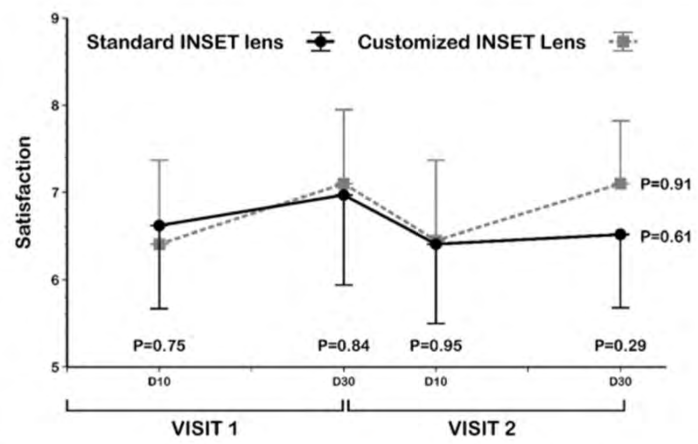
Visual satisfaction with progressive addition lenses prescribed with novel foveal fixation axis measurements

Garcia-Espinilla Oscar[1,2,3], Sanchez Irene[1,2,3] & Martin Raul[1,2,3]

Progressive addition lens (PAL) prescription is usually conducted using the pupillary centre as a reference, which in general does not coincide with the visual axis (kappa distance), and this difference could induce undesired prismatic effects in far and near vision distances and adaptation problems. This study aimed to assess the impact on subjects' visual satisfaction with PALs prescribed based on foveal fixation axis (FFA) measurements. Two different PALs (LifeStyle 3i, Hoya Lens Iberia) were randomly prescribed [one with a customized inset (the difference between the FFA measurements (Ergofocus®, Lentitech, Spain) at far and near distances and the second with a standard inset (2.5 mm)] to be used by 71 healthy presbyopic volunteers in a prospective double-masked crossover clinical study involving one month of use of each PAL. Patients were self-classified into four groups according to their previous experience with PALs: neophyte, PAL users, PAL drop-out, and uncomfortable PAL users. Visual function and overall satisfaction with each PAL were collected and compared. Ninety-seven percent (95% CI 93–100%) of participants successfully adapted to PALs prescribed with FFA without significant differences ($P = 0.26$) among the study groups (100% neophyte and uncomfortable PAL users (95% CI 100% in both groups), 89% (95% CI 67–100%) PAL users and 94% (95% CI 82–100%) PAL drop-out group). There were no statistically significant differences in visual function ($P > 0.05$) between customized and standard inset PALs. Customized and standard inset lenses showed similar satisfaction ($P > 0.42$) that increased significantly ($P < 0.01$ without any carry-over effect) after 30 days of wear. PALs prescribed with FFA measurements showed high visual satisfaction, suggesting that these measurements are suitable for prescribing PAL adaptation processes. Additional research is necessary to assess differences in PAL users' performance with different prescription methods and lens designs.



Group	Lens	Day 10	Day 30	P	Percentage of change
Global (n = 71)	Standard IL	6.56 ± 2.34	6.91 ± 2.24	< 0.01	17.71 ± 86.34
	Mean ± SD (95% CI)	(6.01 to 7.12)	(6.38 to 7.45)		(− 3.03 to 38.45)
	Customized IL	6.37 ± 2.41	7.06 ± 2.11	< 0.01	32.75 ± 100.81
	Mean ± SD (95% CI)	(5.80 to 6.95)	(6.56 to 7.06)		(8.53 to 56.96)
	P	0.42	0.89	–	0.04
Neophyte (n = 27)	Standard IL	6.93 ± 2.30	7.19 ± 2.17	0.11	5.91 ± 13.88
	Mean ± SD (95% CI)	(6.02 to 7.84)	(6.33 to 8.04)		(0.41 to 11.40)
	Customized IL	6.44 ± 1.87	7.15 ± 1.89	< 0.01	17.15 ± 39.48
	Mean ± SD (95% CI)	(5.71 to 7.18)	(6.40 to 7.90)		(1.53 to 32.77)
	P	0.14	0.66	–	0.19
PALs users (n = 10)	Standard IL	6.90 ± 2.23	6.80 ± 2.90	0.79	− 2.46 ± 24.92
	Mean ± SD (95% CI)	(5.30 to 8.50)	(4.73 to 8.87)		(− 20.29 to 15.37)
	Customized IL	6.80 ± 2.62	7.30 ± 2.00	0.24	17.12 ± 34.48
	Mean ± SD (95% CI)	(4.93 to 8.67)	(5.87 to 8.73)		(− 7.54 to 41.79)
	P	0.73	0.81	–	0.07
PALs drop out (n = 17)	Standard IL	6.35 ± 2.69	7.12 ± 2.29	0.06	51.71 ± 169.02
	Mean ± SD (95% CI)	(4.97 to 7.74)	(5.94 to 8.29)		(− 35.19 to 138.62)
	Customized IL	6.06 ± 3.07	7.00 ± 2.34	0.09	73.88 ± 189.34
	Mean ± SD (95% CI)	(4.48 to 7.64)	(5.79 to 8.21)		(− 23.47 to 171.23)
	P	0.72	0.72	–	0.64
Uncomfortable PALs user (n = 17)	Standard IL	6.00 ± 2.15	6.31 ± 1.96	0.13	12.98 ± 27.86
	Mean ± SD (95% CI)	(4.89 to 7.11)	(5.27 to 7.36)		(− 1.86 to 27.83)
	Customized IL	6.31 ± 2.50	6.82 ± 2.40	0.09	18.92 ± 48.48
	Mean ± SD (95% CI)	(4.98 to 7.64)	(5.59 to 8.06)		(− 6.91 to 44.76)
	P	0.62	0.37	–	0.58

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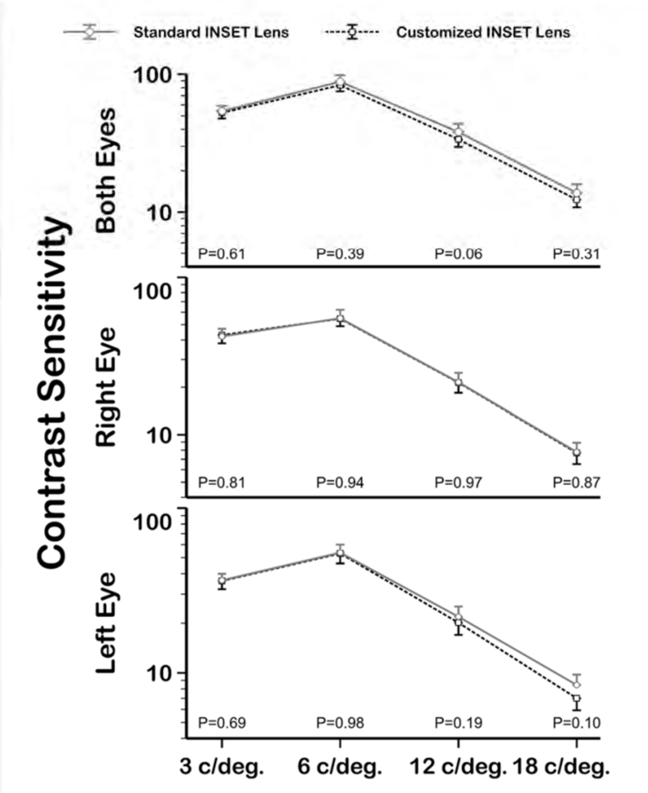
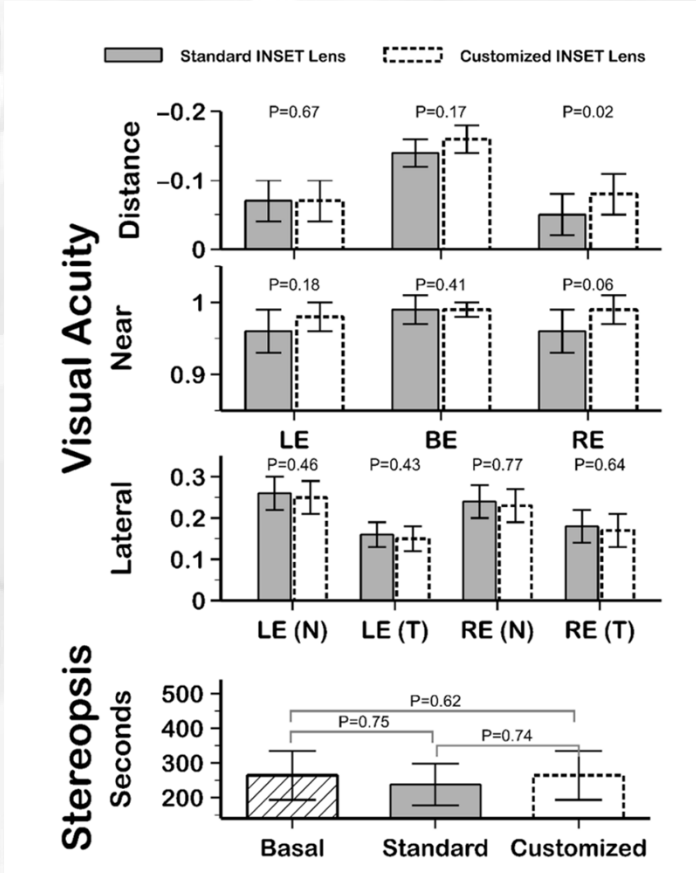
OPEN Visual satisfaction with progressive addition lenses prescribed with novel foveal fixation axis measurements





CUSTOMIZATION OPTHALMIC LENSES

A good level of customization of ophthalmic lenses has been achieved, but…

…could it be done even better?

It is possible with AI!!

AI-BASED PRESCRIPTION AND DESIGN OF OPHTHALMIC LENSES

	Addition												
Sphere	0,75	1,00	1,25	1,50	1,75	2,00	2,25	2,50	2,75	3,00	3,25	3,50	Total Sphere
-11,00	0,00%	0,00%	0,00%	0,00%	0,00%	0,01%	0,02%	0,02%	0,00%	0,00%	0,00%	0,00%	0,05%
-10,00	0,00%	0,00%	0,00%	0,01%	0,02%	0,02%	0,02%	0,03%	0,01%	0,00%	0,00%	0,00%	0,12%
-9,00	0,00%	0,00%	0,00%	0,02%	0,02%	0,04%	0,04%	0,06%	0,02%	0,01%	0,00%	0,00%	0,22%
-8,00	0,00%	0,01%	0,02%	0,03%	0,04%	0,06%	0,08%	0,10%	0,03%	0,02%	0,00%	0,00%	0,38%
-7,00	0,00%	0,01%	0,03%	0,05%	0,07%	0,11%	0,14%	0,17%	0,05%	0,03%	0,00%	0,00%	0,66%
-6.00	0,00%	0,02%	0,05%	0,09%	0,11%	0,17%	0,24%	0,29%	0,08%	0,04%	0,00%	0,00%	1,08%
-5.00	0,00%	0,03%	0,07%	0,12%	0,16%	0,27%	0,36%	0,45%	0,13%	0,06%	0,00%	0,00%	1,65%
-4.00	0,00%	0,06%	0,10%	0,18%	0,22%	0,38%	0,56%	0,68%	0,19%	0,09%	0,00%	0,00%	2,47%
-3,00	0,02%	0,08%	0,13%	0,24%	0,29%	0,50%	0,75%	0,98%	0,29%	0,16%	0,02%	0,00%	3,45%
-2,00	0,03%	0,10%	0,16%	0,27%	0,34%	0,59%	0,94%	1,25%	0,38%	0,21%	0,02%	0,01%	4,30%
-1,00	0,04%	0,13%	0,24%	0,42%	0,56%	0,90%	1,31%	1,68%	0,54%	0,36%	0,04%	0,02%	6,25%
0,00	0,31%	0,99%	1,47%	2,43%	3,12%	4,61%	6,07%	7,92%	3,14%	2,16%	0,28%	0,14%	32,64%
1.00	0,09%	0,26%	0,42%	0,82%	1,45%	3,05%	5,08%	6,70%	2,59%	1,54%	0,18%	0,08%	22,25%
2.00	0,03%	0,10%	0,14%	0,29%	0,54%	1,27%	2,82%	4,60%	1,96%	1,17%	0,13%	0,05%	13,12%
3.00	0,02%	0,06%	0,08%	0,15%	0,24%	0,54%	1,15%	2,07%	0,99%	0,58%	0,09%	0,03%	5,99%
4.00	0,00%	0,03%	0,05%	0,10%	0,14%	0,29%	0,54%	0,87%	0,37%	0,22%	0,03%	0,01%	2,66%
5.00	0,00%	0,02%	0,03%	0,06%	0,09%	0,18%	0,29%	0,44%	0,17%	0,09%	0,01%	0,00%	1,38%
6,00	0,00%	0,00%	0,02%	0,03%	0,05%	0,11%	0,16%	0,27%	0,09%	0,05%	0,00%	0,00%	0,77%
7,00	0,00%	0,00%	0,00%	0,02%	0,02%	0,05%	0,09%	0,13%	0,05%	0,03%	0,00%	0,00%	0,38%
8,00	0,00%	0,00%	0,00%	0,00%	0,00%	0,02%	0,03%	0,05%	0,02%	0,01%	0,00%	0,00%	0,13%
9,00	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,01%	0,02%	0,00%	0,00%	0,00%	0,00%	0,03%
Total Addition	0,53%	1,92%	2,99%	5,34%	7,47%	13,16%	20,70%	28,78%	11,11%	6,83%	0,81%	0,34%	

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AI-BASED OPHTALMIC LENSES

- AI: further optimization of the customization of ophthalmic lenses, based on a series of calculations with individual parameters:
  - Corneal curvature radius
  - Corneal topographic map TOPOGRAFIA CORNEALE
  - Ocular HOAs
  - User needs
  - Even eye movement recordings

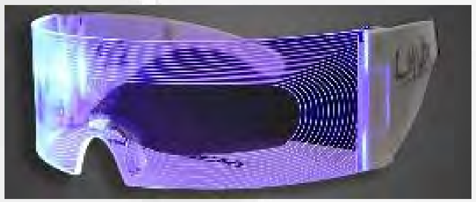
- Aim: hyper-personalised solutions, significantly shorter adaptation times, enhanced visual performance and quality of life

AI-BASED OPHTALMIC LENSES

- Vast datasets of information relating to eyes and vision, trends of vision defects, binocular vision anomalies, biometric data → collected, organized and stored in a platform

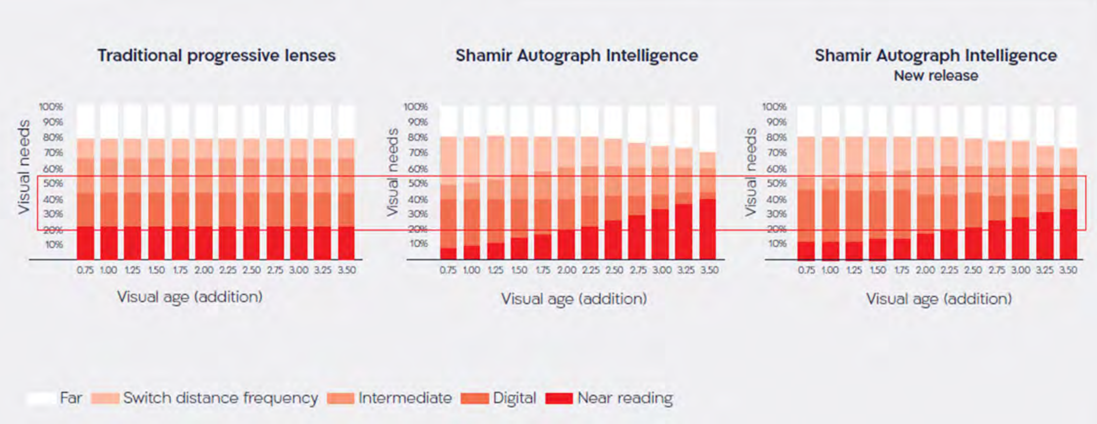
    - MACHINE LEARNING
        - Identification of patterns, relationships and characteristics that will improve the design of ophthalmic lenses

- AI also useful in the eyeglass lens design process → creation of personalized models for each individual, considering variables such as prescription, eye movements, patient preferences or lifestyle

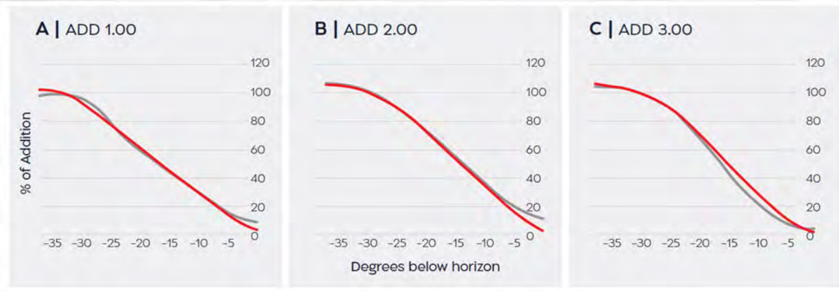


AI-BASED OPHTALMIC LENSES

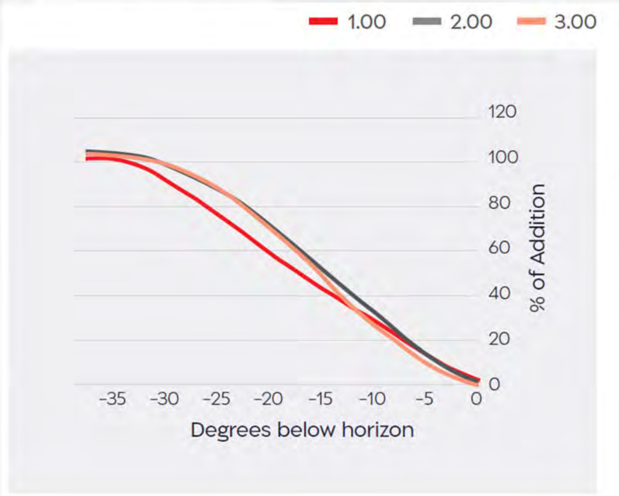
- Shamir Autograph Intelligence: an intelligent, learning, and continuously improving lens design
  - Adjustments of the design profiles through Visual AI Engine™ technology, resulting in updated design profiles
  - Controlled gradual change of the 12 updated designs, using Continuous Design™ Technology, together forming one advanced, easy to adapt updated product
  - Improved digital abilities by improving intermediate vision thanks to IntelliCorridor™ Technology



AI-BASED OPHTALMIC LENSES



- Shamir Autograph Intelligence

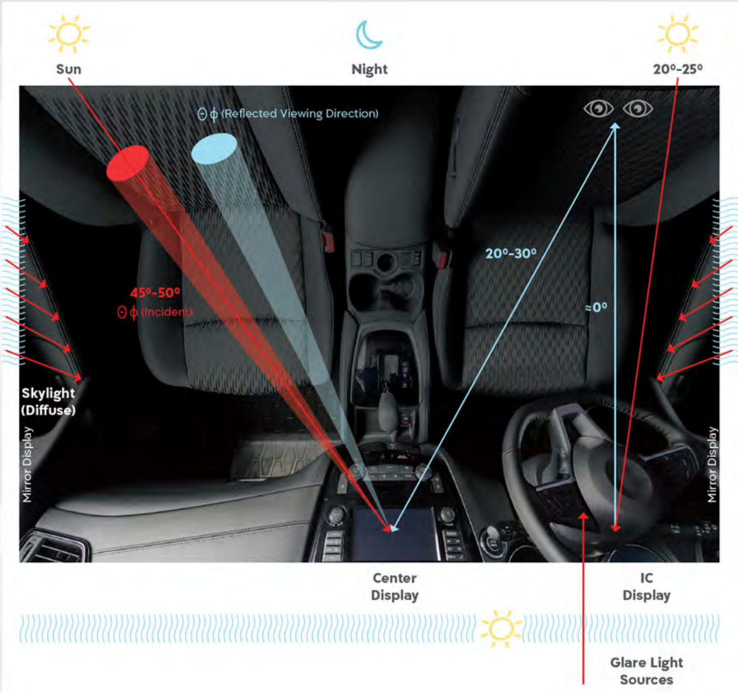


VISUAL AGE™	OPTICAL DESIGN IMPROVEMENTS	VISUAL ASPECT IMPROVEMENTS
EMERGING PRESBYOPES	• Reduction of Add at fitting point • Wider Corridor • Power profile: linear profile and reduction of addition at the beginning of the corridor • Lower maximum cylinder (astigmatism) • Softer* design (lower gradients) • Significantly wider near vision * less aberration at the center and corridor	• Improved visual acuity at fitting point to increase far vision comfort • Wider digital field of view for increased comfort • Power profile allowing greater lens softness and easier adaptation • Better adaptation and digital vision • Better adaptation and digital vision • Increased reading comfort
ESTABLISHED PRESBYOPES	• Reduction of Add at fitting point • Wider corridor • Power profile: almost identical to current version of Autograph Intelligence™ while reducing the addition at the beginning of the corridor • Wider near vision	• Improved visual acuity at fitting point to increase far vision comfort • Wider digital field of view for increased comfort • Power profile: Improved visual clarity and faster adaptation • Increased reading comfort
ADVANCED PRESBYOPES	• Wider far vision • Reduction of add at fitting point • Power profile: smoother and faster power progression • Lower maximum cylinder • Wider near vision	• Greater field of view for better far vision • Improved visual acuity at fitting point to increase far vision comfort • Power profile: better comfort in the digital field of view and accommodation support throughout the intermediate zone • Better adaptation and more digital viewing comfort • Increased reading comfort

AI-BASED OPHTALMIC LENSES

- Shamir Driver Intelligence

- Night myopia, more prevalence in younger drivers: accommodation shift occurring at low light levels
  - Night myopia > 0.75 D affect 17% of individuals aged 16-80 and 38% of those aged 16-25
- Sun glare is a significant risk for drivers
  - It is a factor in traffic accidents.
- Bright sunlight is associated with an increased risk of a life-threatening motor vehicle crash
- Visual acuity declines at night
- Contrast sensitivity declines at night
- Reaction time increases at night compared to daytime
- Color perception is changed at night compared to daytime
  - Reduction in the quality and gamut of perceived color
- Hue perception is changed at night compared to daytime



	L_g(cd/m²)	E_l(lx)
Direct sunlight	-	2k - 100k
Cloudless sky	1.4 - 4.4k	
Cloudy	6k - 20k	500 - 10k
Rain	40 - 500	50 - 1.3k
Twilight	0.8 - 400	3 - 500
Night	0.05 - 10	0 - 50
Average glare light source	1k - 5k	-

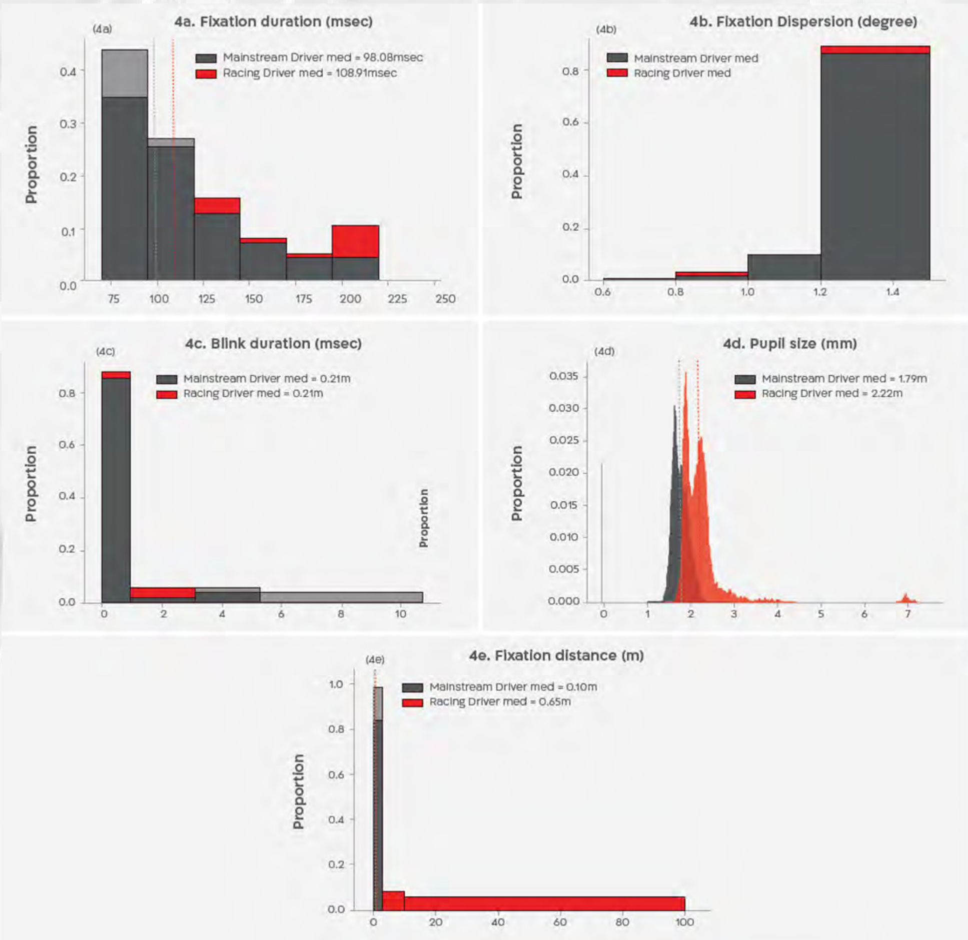
AI-BASED OPHTALMIC LENSES

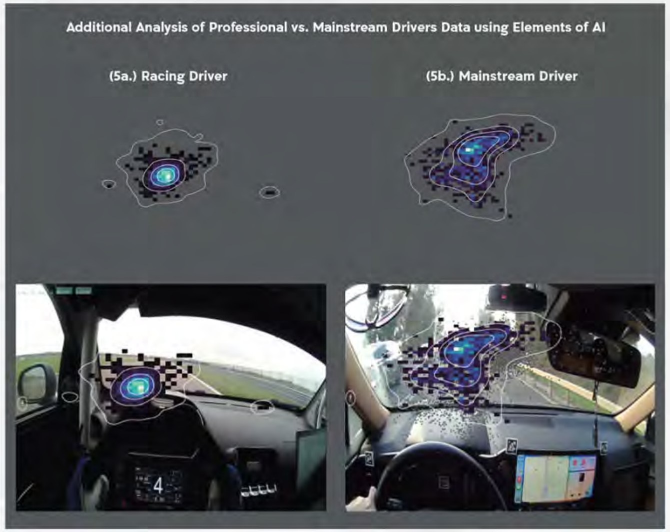
- Shamir Driver Intelligence: data collected and analyzed
  1. Distances
  2. Angles (gaze and head orientation)
  3. Total fixation time
  4. Total saccade time
  5. Median fixation duration
  6. Median fixation dispersion
  7. Percentage dwell time on the road ahead
  8. Distribution estimation of fixation in driving environment

- ❑ Pupil Core eye-tracking glasses - for recording eye movements
- ❑ Vivior Sensor- for head posture and head movements
- ❑ Smart Eye remote eye tracker - for recording eye movements.
- ❑ HEIM - a platform for integrating head and eye movements
- ❑ iMotion data integration and analysis software -for integration of data

AI-BASED OPHTALMIC LENSES

- Shamir Driver Intelligence: data collected and analyzed



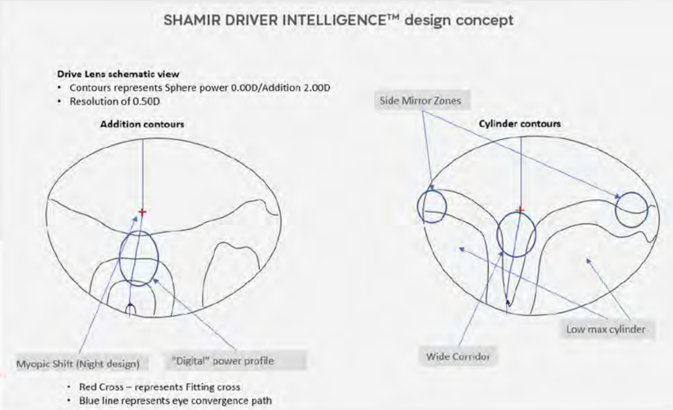


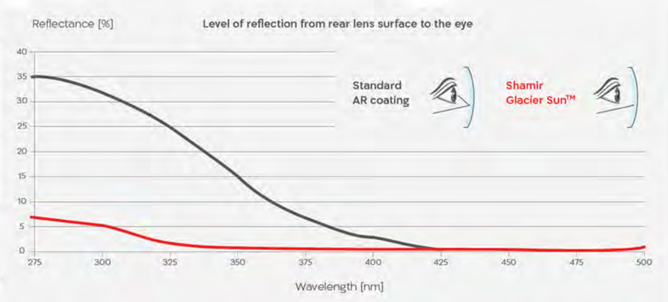
AI-BASED OPHTALMIC LENSES

- Shamir Driver Intelligence

E.1 Shamir Driver Intellgence™ General Overview - Features vs. Visual Driving Challenges

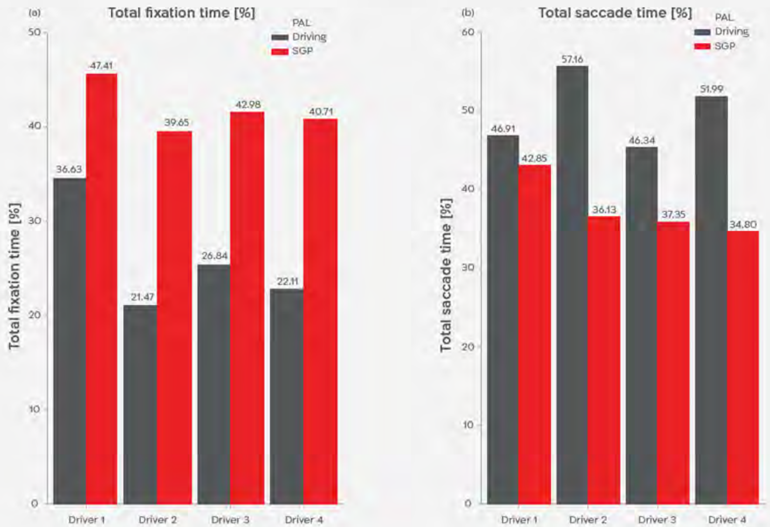
Visual challenges experienced by drivers	SDI features designed to address each challenge	Benefits of SDI feature compared to Shamir General Purpose (SGP) lens
Night myopia, higher prevalence among younger drivers	**Unique product design incorporates a myopic shift based on visual age**	Night myopia reduction as a function of age
Constant need to direct gaze to objects requiring over a 30º eye rotation (need for constant head rotation)	**Unique design incorporates wider and clearer visual fields in areas of interest**	Minimal head movement, more eye movement, improved ability to comfortably scan surroundings
Sun glare	**Coatings (Day) Shamir Glacier Sun UV™**	Sun glare reduction
Decline of visual acuity at night	**Coatings (Night) Shamir Glacier Expression™**	Improved acuity at night
Decline of contrast sensitivity at night		Improve contrast sensitivity at night
Increased reaction time at night		Faster reaction at night
Changed hue perception	**Color enhancement**	Improved hue differentiation* during daylight *At NC effective filter zone
Changed color perception		Better color perception during daylight
High cognitive load while driving	**Expected overall benefits**	Less cognitive load experienced while driving





AI-BASED OPHTALMIC LENSES

- Shamir Driver Intelligence



AI-BASED OPHTALMIC LENSES

- Shamir Driver Intelligence

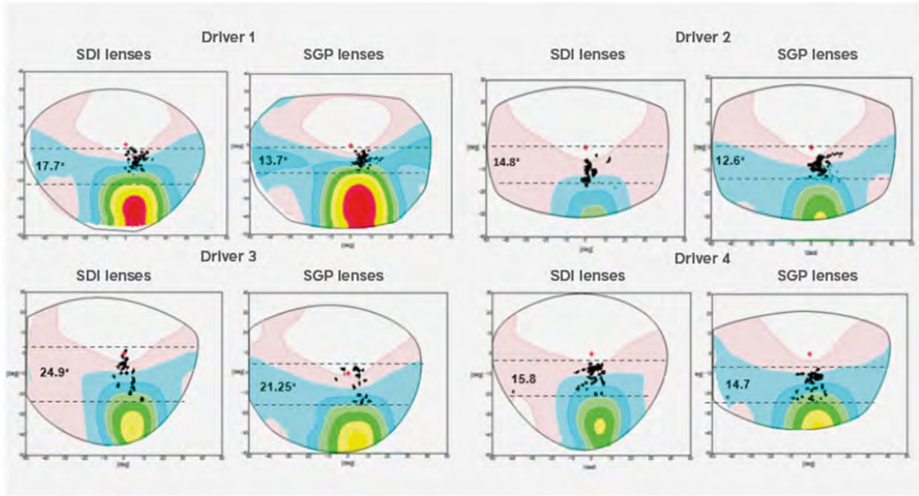


Figure 23. Cylinder and Add maps with gaze points on lens. Vertical visual field width comparison between SDI and SGP lenses.

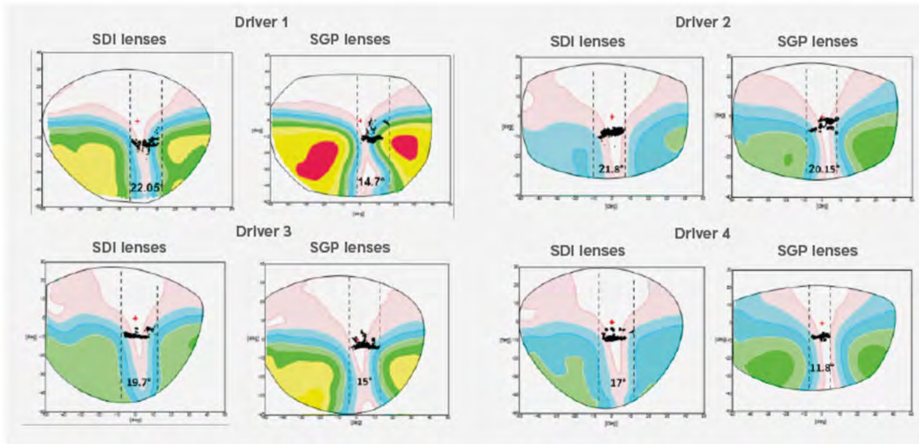


Figure 24. Cylinder map with gaze points on lens. Comparison of horizontal visual field width, between SDI and SGP lenses.

AI-BASED OPHTALMIC LENSES

- Shamir Driver Intelligence

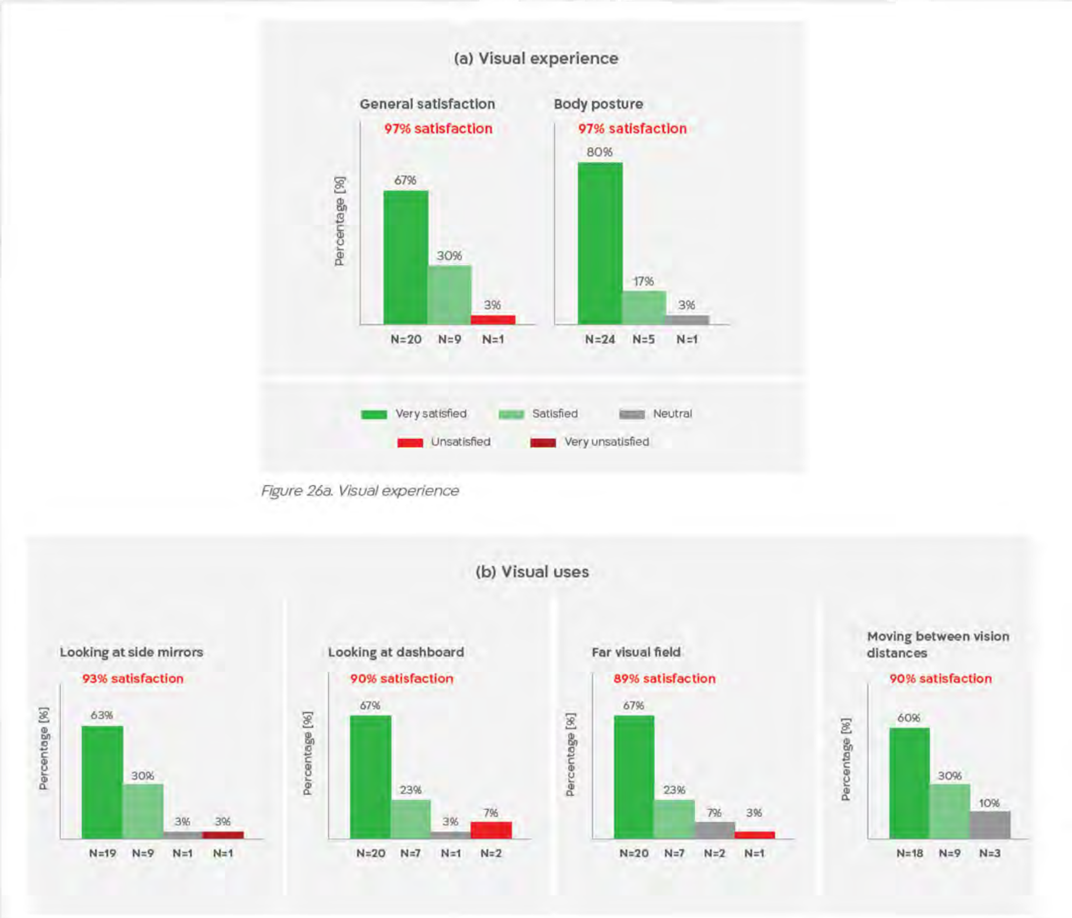
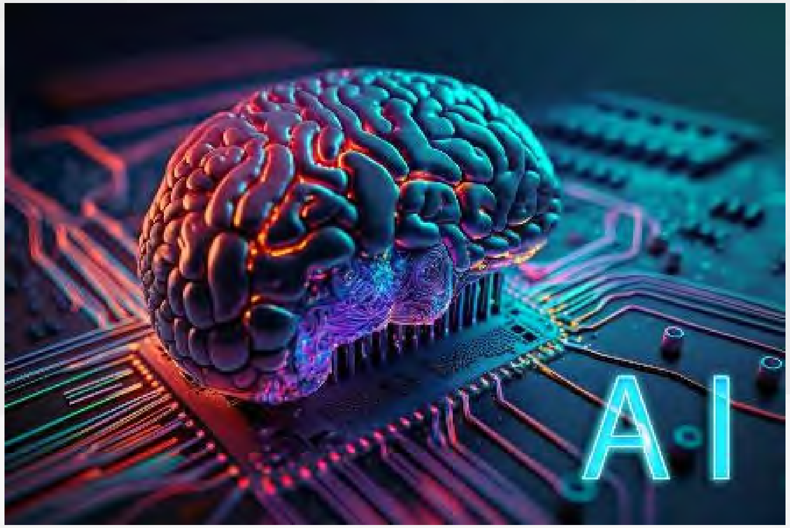


Figure 26a. Visual experience

CONCLUSIONS



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CONCLUSIONS

- AI is revolutionizing many sectors including ophthalmology, ophthalmic telemedicine and ophthalmic optics
- AI is being integrated into the design and development of ophthalmic lenses, with the aim of improving the quality of life of users suffering from visual problems
- AI is able to process a large amount of data including eye movement recordings
- AI will be used to optimized ophthalmic lenses designs thanks to the development of sophisticated algorithms considering variables such as prescription, eye movements, patient preferences, lifestyles and others
- Some examples of AI-based ophthalmic lenses are already available: Shamir Autograph Intelligence, Shamir Driver Intelligence

FUTURE IS HERE

THANK YOU VERY MUCH

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