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PRODUCT SPOTLIGHT – ZEISS SMARTLIFE LENS TECHNOLOGY

SMARTLIFE: THE EVOLUTION OF LENS DESIGN FOR DYNAMIC CONNECTIVITY

A Complete Premium Lens Portfolio for a Connected, On-the-Move Lifestyle—No Matter the Age

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[1 CE CREDIT]

NEW VISUAL AND POSTURAL DEMANDS ARISE FROM DYNAMIC DIGITAL CONNECTIVITY

The year 2007 irrevocably changed our lives with the introduction of the iPhone. Ever since pocket-sized computers from Apple, Samsung and others, we have lived with 24/7 mobile internet access. The impact of this digital connectivity and interactivity extends to all generations. We are rarely parted from our pocket computers/phones/smartphones and frequently use them while in motion. This intensive digital connectivity and interactivity have profound impacts on vision and posture. We have entered a new dimension of "multi-tasking," a word that somehow fails to capture the external world's direct connection to us and the effects on our plethora of choices in any given moment. For this reason, ZEISS has coined the phrase dynamic connectivity to describe our new in motion digital connectivity and its impact on vision needs.

In today's digitally connected, in motion lifestyle, our visual requirements are dynamic with frequent gaze changes in numerous directions while focusing at varying distances. Our visual habits and requirements have changed to accommodate the various screen-based digital technologies that permeate our lives from handheld smartphones, aka pocket computers and tablets. There isn't a one-size-fits-all lens solution as the visual requirements change with age. ECPs need a complete premium lens portfolio to address the evolution of visual requirements of the on-the-go digitally connected lifestyle as we transition from single vision into lenses that assist our view of digital device screens until we require progressive lenses with nearly full loss of accommodation.

NEW VISUAL HABITS = NEW VISION CHALLENGES

The last decade has seen a rapid change in visual habits due to handheld digital devices. These pixelated screens have higher resolution displays with a considerably smaller viewing area compared to laptop and personal computer monitors. These high-resolution screens display finer details than most printed books. Researchers showed that when viewing Web content on a smartphone, typical viewing distances are about 32 cm, a distance that is closer than the distance of conventional exam refraction. This average device viewing distance is closer than the distance for which standard multifocal lenses are designed to be used. Initially, spectacle lens designers approached this new visual habit the same as traditional reading behavior but with a closer viewing distance. Mistakenly, a person was presumed to be stationary when reading their smartphones; however, dynamic connectivity results in handheld device use while in motion, even while walking. More than half of all respondents in a recent study reported looking at their smartphones even while climbing stairs.

LEARNING OBJECTIVES:

Upon completion of this program, the participant should be able to:

1. Learn about the unique visual challenges facing us due to the dynamically connected modern lifestyle.
2. Learn about the visual challenges caused by the physiological changes of the aging eye.
3. Learn about an adaptive lens technology that changes with the digitally connected wearer's age-related vision requirements.

To Earn Continuing Education Credit:
This course has been approved for one (1) hour of Ophthalmic Level II continuing education credit by the American Board of Opticianry (ABO). To take this course and earn 1 hour credit, visit 2020mag.com/ce to review the course, the self-assessment questions and take the exam.

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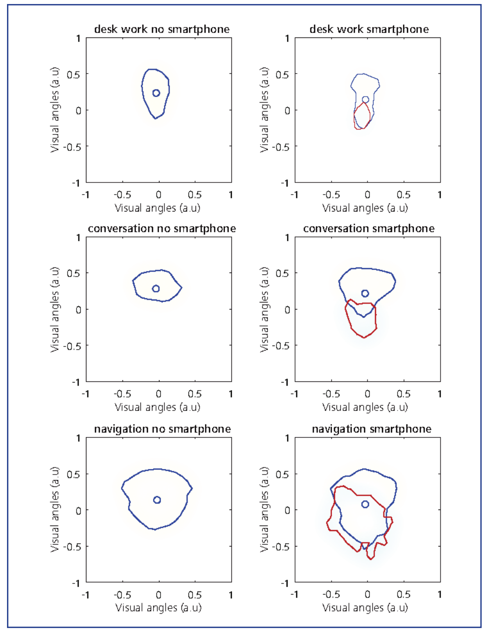
FIG. 1 Eye movements with and without smartphones. Scale represents arbitrary units defining the range of detectable eye movements. The blue and red circles represent the centers-of-mass of the non-smartphone and smartphone isolines (ZEISS Study 1).



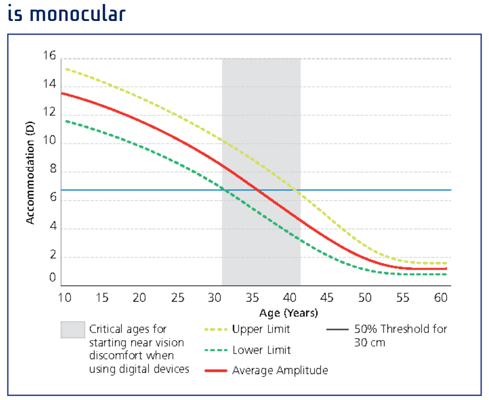
DYNAMIC CONNECTIVITY – CHANGING POSTURAL HABITS

When viewing device screens, we are most comfortable with our arms and elbows close to the body and with our hands positioned close to the torso and below the head. A recent five year study showed that users of handheld devices must bend the upper spine and tip the head forward to adapt to this position. But bending the neck forward still requires downward eye rotation to view our smartphone screen. A recent ZEISS research study showed that spectacle wearers using smartphones turn their eyes to look lower through their lenses, including when performing deskwork, in conversation and while walking. One consequence of this change is that wearers use a larger area of their lenses for a broader range of visual fixations (ZEISS Study 1). Fig. 1 shows the measurements made of the difference in eye movement patterns when using a mobile device. Eye movements when using the smartphone were shifted significantly downward, and the overall area of the lens accessed for vision increases.

CHANGING VISUAL CAPACITIES ACCORDING TO AGE

Traditionally ophthalmic optics teach that accommodative amplitude declines with age until the reserve of accommodation no longer allows sustained and comfortable near focus. Fig. 2 graph shows the distribution of the monocular amplitude of accommodation as a function of age. To provide spectacles that will enable at least a 50 percent reserve of accommodation, most people would require an addition power by age 40 when looking at very close objects. The problem with this monocular perspective is that it does not account for dynamic binocular vision. Accommodation is part of an age-dependent multifactorial binocular visual reflex. There are two components of accommodation: The stronger component is driven by binocular convergence while the weaker component is a response to blur. The response dynamics depend on whether vision changes from far to near ("accommodation") or from near to far ("disaccommodation"). In young people, the accommodation amplitude is greater when the head is pointing face down, but this same effect is not observed in older people. This is an age-related vision factor to consider for mobile device use since the head posture is typically turned downward.

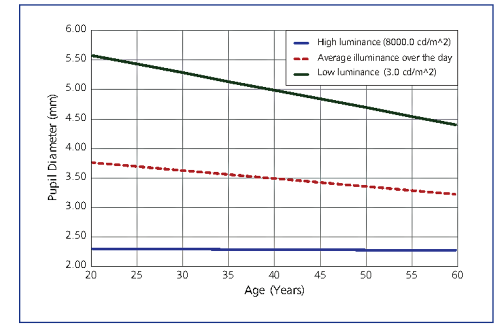
FIG. 2 The traditional view of accommodation is monocular



With age, the convergence-accommodation complex changes. Depth of focus increases with age, resulting in a slower accommodative response. The effect of increased depth of focus is reduced input to the blur-driven accommodation response, reduced convergence-accommodation to convergence ratio (CA/C) and a slower response reaction time, all of which affect spectacle lens design. The stages of progression through changes in the accommodative convergence response traditionally are addressed with separate spectacle lens products, including single vision, digital use lenses and progressive addition lenses. These types of lenses and their uses are well known to eyecare professionals. At first, young lens wearers have very responsive and flexible accommodation and require only a single vision lens. As we age, we reach a stage where the accommodative amplitude is reduced as a consequence of loss of flexibility of the crystalline lens to change its shape to focus on near objects. A reduction in accommodative amplitude can cause binocular vision stress because convergence and divergence remain fast and accurate while focus lags. This is particularly true for close viewing of handheld devices. Some people become symptomatic, complaining of eyestrain or blurry vision, and the solution is to provide a small amount of addition power to reduce accommodative load. This was the concept behind the introduction of ZEISS Digital Lenses. The specific application of this new lens type was further confirmed in a recent study conducted by the Aston Optometry School of Aston University (UK). The researchers found that SmartLife Digital Lenses significantly improved the accommodative response, thereby providing increased visual acuity while reducing the lag of accommodation for near stimuli (3D and closer, that means tasks performed closer than 33 cm) after a concentrated near-work task in 30 to 40 year olds (ZEISS Study 2).

With presbyopia, progressive lenses are required to sustain accomodation over a range of distances. However, accommodation is not the only visual response that changes with age. The pupillary light reflex is the pupil's response to light. The pupil constricts in light and dilates in the absence of light. The ability of the pupil to constrict is limited by basediameter, which is relative to its ability to dilate. The dilation response decreases with age resulting in average pupil size to reduction. Fig. 3 shows one set of data for two levels of illumination, according to Watson and Yellot.

FIG. 3 Pupil diameter as a function of age after (Watson and Yellot, 2012)



Changes of pupil size affect retinal illuminance and depth of focus; both of those, in turn, affect acuity.

Furthermore, pupil diameter is key when calculating the magnitude of aberrations in spectacle lenses. Age-related changes in pupil size can significantly affect the utility of spectacle lenses. All of these changes to accommodation and pupil diameter must be considered when evaluating and responding to the changing demands of dynamic connectivity.

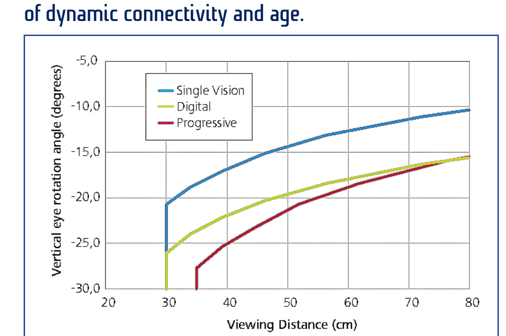
SmartLife Technologies is a lens design technology developed to address the visual requirements of people interacting with their handheld devices. SmartLife lenses are based on four design principles that, in combination, meet the individual requirements of a dynamic, connected lifestyle for adults of all ages. Clear Optics provides precision in every step of lens design and fabrication; Thin Optics improves aesthetics by achieving the best in thin and light lenses. Together, Smart Dynamic Optics and Age Intelligence establish a new technology platform called SmartView. These new technologies provide a new object space model that accounts for today's visual dynamics while providing a smoother distribution of powers to improve vision during eye movements that cover a larger area of the lens. This is an adaptive lens design technology to address every visual stage of our life.

Age Intelligence technology accounts for the change in pupil size according to the wearer's age, and it is an important aspect of the SmartLife lens design concept. This new lens design method improves upon ZEISS Luminance Design Technology 2.0 by calculating dioptric powers using the entire beam of light passing through the pupil instead of using a chief ray without considering the real pupil diameter. SmartLife lens design technology determines pupil size by the wearer's age. Age may be provided with an order, otherwise add power will be used to define the wearer's age. Age is compared to a table of expected values of pupil size similar to the data shown in Fig. 3, and the chosen pupil size is a parameter used in the lens design software optimization calculation to determine the prescription surface and generate a data points file for the application of the design to the lens surface. Pupil size as a parameter in lens surface calculations influences the targeted distribution of lens powers and viewing distances established by a new object-space model.

OPTICS CORRECTED FOR DYNAMIC ACCOMMODATION

As mentioned, studies show that people are increasingly viewing at closer distances and using more of the lens. ZEISS researchers find that changes in gaze angle result in the wearer's eye positioned lower in the lens. SmartLife lenses introduce a new unified approach to define the binocular viewing distance according to the vertical gaze angle. SmartLife Single Vision, Digital and Progressive Lens designs incorporate distributions of dioptric power according to the requirements of a wearer by the prescribed addition power. Age Intelligence technology applies research and experience, and adapts each lens design to accommodate changes in pupil size and dynamic accommodation differences for adults according to the wearer's age. The fastest-growing segment of smartphone users is among people older than age 55. Age Intelligence technology is a guide for the accommodative-convergence capabilities of wearers by age and progress from single vision to multifocal lenses.

FIG. 4 These curves are for average frames with standard corridor length. The new ZEISS object space model takes into account the requirements of dynamic connectivity and age.

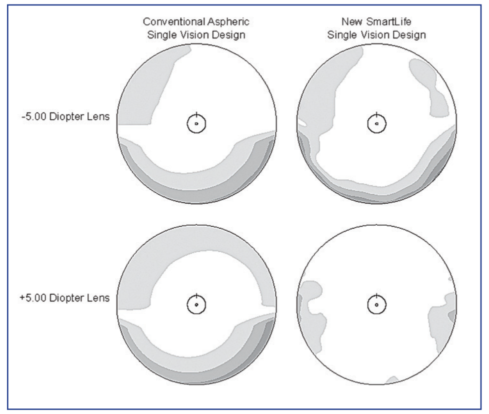


Smart Dynamic Optics is an object-space model that allows the optical lens design engineers to simulate dynamic visual behavior, whether it be near vision or far vision. The distribution of dioptric power in the lens produces improved peripheral optics by minimizing oblique astigmatism. The lens has a flatter profile and smoother progression from near to far and far to near maintaining crisp, clear vision despite the frequent postural changes and eye rotation/gaze/distance changes of today's active, connected adults. Smart Dynamic Optics defines the relationship between gaze angle and object distance. Together with Age Intelligence technology, they provide a new object-space model of the relationship between vertical gaze angle, binocular viewing distance and values of dioptric mean power for each lens type and prescribed addition power. Fig. 4 shows the relationship between vertical gaze angle and viewing distance used to create the three classes of SmartLife Lenses. To understand how this new model works, it is necessary to see how it is applied for each type of lens.

Single vision lens wearers not only have a large amplitude of accommodation; their accommodation and disaccommodation responses are rapid. Furthermore, in the typical head-down and eye-down posture used for handheld devices, a young person's accommodative amplitude is enhanced. On the other hand, the significant downward eye rotation angle and very close viewing distance require a different lens surface shape in the lower portion of the lens than the optimum shape for large horizontal eye movements along the horizon in the upper lens region.

SmartLife Single Vision Lenses use the object space model to calculate an individually designed freeform surface according to the

FIG. 5 SmartLife Single Vision Lenses achieve clearer vision by reducing oblique astigmatism error throughout the lens



position of wear that minimizes oblique astigmatic errors for all viewing distances over the entire range of the object space model. The change in viewing distance proceeds smoothly from infinity when viewing straight ahead to 30 cm at a 20-degree downward gaze angle.

Fig. 5 shows a significant improvement in the clarity of the visual fields of SmartLife Single Vision Lenses compared to standard single vision designs. A complete analysis of SmartLife Single Vision Lenses over a range of prescriptions and viewing distances revealed improved optical performance with up to 88 percent larger clear fields of view.

SmartLife Digital Lenses also have been improved using the new object space model. In contrast to SmartLife Single Vision Lenses, the model for SmartLife Digital Lenses transitions to closer distances starting at a point lower in the lens. This avoids interference with far vision for those accustomed to single vision lenses or no lenses. At 15 degrees downgaze, a very small increment of addition power is set for viewing at 80 cm; by 25 degrees downgaze, the addition power has reached its full value, and the model viewing distance has zoomed in to 30 cm, the same as for SmartLife Single Vision Lenses. This new design approach reduces overall blur levels compared to previous ZEISS digital lenses. SmartLife Digital Lenses may be ordered by the eyecare professional with addition powers between +0.50 and +1.25 diopters. By the time a person is presbyopic, it is no longer possible to sustain accommodation for the closest viewing distances, and comfortable viewing of intermediate-range objects is also compromised by an amount that depends on age.

Although the new ZEISS object space model for SmartLife Digital and Progressive Lenses is set to about 80 cm at 15 degrees downgaze, the specifications are different at closer viewing ranges. This is because progressive wearers require a wide intermediate visual field. A progressive lens with a corridor that is too short would be unusable at 50 to 80 cm, so SmartLife Progressive Lenses are available with variable corridor lengths.

SmartLife Single Vision and Digital Lenses are designed for the closest viewing distance of 30 cm; SmartLife Progressive Lenses are designed for the closest viewing distance of 35 cm. This is to allow the prescribed addition power to function better over a wider range of close viewing distances.

The three stages of correction and corresponding lens types are treated as a unified transitional approach in ZEISS SmartLife. SmartView Technology establishes the requirements of the new object-space model. Smart Dynamic Optics provides a new relationship between viewing distance and gaze angles for today's connected lifestyle. Age Intelligence establishes the new relationship between viewing distance and the prescribed addition power. SmartLife Lenses provide a single integrated approach for managing the dynamic relationships between vertical viewing angles and viewing distance in single vision, digital and progressive lenses.

A REALIGNMENT OF DESIGN GOALS

To keep up with the rapid pace of our connected lifestyle, SmartView Technology utilizes design technologies such as Smart Dynamic Optics to account for the environmental and ergonomic (postural) challenges presented by dynamic connectivity, while Age Intelligence technology applies ZEISS research and experience to the differing characteristics and abilities of adults of all ages, whether they wear single vision, digital or progressive lenses. SmartLife Lenses are the first comprehensive application of lens design to a continuous range of lenses adapted for the evolution of age related vision changes.

OPTICS DESIGNED FOR NEW VISUAL PATTERNS

Today people are using connected devices for many activities, and as we have seen, more areas of the lens are used for visual fixations. This is important in single vision lenses and even more important in multifocal lenses.

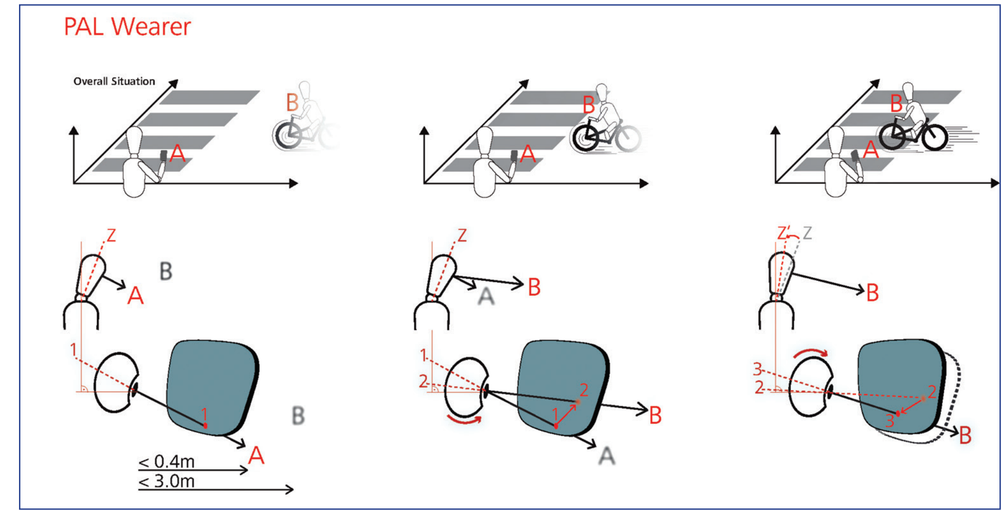
SINGLE VISION

In single vision lenses, the prescription requirement is constant for all gaze angles. SmartLife Single Vision Lenses use the object space model to minimize oblique astigmatism when wearers look down to view a close handheld device and when they look up to see more distant objects. The optimization of the design is achieved to make the change as smooth and imperceptible as possible.

DIGITAL AND PROGRESSIVE LENSES

In digital and progressive lenses, the situation is quite different; a progressive increase in addition power in the lens corridor produces peripheral distortion, astigmatism and power errors. These peripheral areas include astigmatic errors and also values of mean power that do not match all possible viewing distances. When an object of interest presents itself to the peripheral vision of a person viewing a handheld device, the resulting eye movements may follow a path where power errors and astigmatism are notable to the wearer. Fig. 6 shows an example. Consider a pedestrian who wears progressive addition lenses and is using a smartphone while walking on a city sidewalk. His attention is fixed on the smartphone ("A"), but as he walks, a bicyclist ("B") approaches from the right, which he notices with his peripheral vision. Automatically he turns his eyes to view the cyclist, shifting gaze from point 1 on the lens to point 2. A moment later, he lifts his head and continues to follow the cyclist with his eyes for a moment. This sweeps the

FIG. 6 Changes of attention result in new visual scanning patterns across lenses

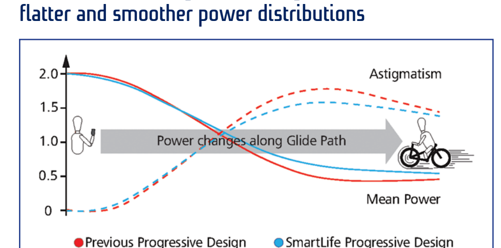


line of sight along the path from point 2 to point 3. Along this viewing path, the addition power and astigmatic aberration of a multifocal lens are changing continuously. Each person and every circumstance will produce a new line-of-sight path as the eyes acquire new targets, like the glide path of a plane coming in for a landing. Each glide path eventually leads back lower in the lens when focused on our handheld device screen. For lens designs to be effective, they must ensure that the distribution of dioptric powers meets the visual needs throughout the region of re-fixations.

The pattern of eye movements of a digitally connected lifestyle requires rethinking the optical design of digital and progressive lenses. Dynamic connectivity leads to spectacle lenses being used for complex and dynamic activities. Therefore, the new power distributions need to be smoother and flatter. Fig. 7 shows an example of the smoother visual glide path in a SmartLife Progressive Lens compared to its predecessor.

In comparison to ZEISS Precision lenses, ZEISS SmartLife Progressive Lenses have smoother transitions into areas of the peripheral blur with a lower level of blur for intermediate and near distances. In a very demanding study of transient target detection in the periphery of SmartLife Progressives (ZEISS Study 3), the enhanced peripheral optics allowed very high levels of performance among the most perceptive wearers.

FIG. 7 SmartLife Digital and Progressive Lenses use flatter and smoother power distributions



WHAT DO THE SMARTLIFE LENS WEARERS REPORT?

In an external acceptance study among participants who live a connected lifestyle, SmartLife Lenses gave 84 percent of single vision, digital and progressive lens wearers all-day visual comfort (ZEISS Study 4). In this study, 94 percent of SmartLife Single Vision wearers perceived wide fields of comfortable vision for intermediate and near vision tasks. Seventy-three percent of SmartLife Digital Lens wearers reported feeling no strain at the end of the day, and the majority reported feeling less eyestrain compared to their habitual lenses. Four out of five SmartLife Progressive wearers experienced smooth vision from near to far across all viewing zones. Although ZEISS provides general guidance for the use of SmartLife Lenses, it is the eyecare professional who is best able to judge when it is time for any person to take the next step in lens type. Fig. 8 illustrates a life timeline that might be applied to any individual. In the early years, a person may or may not have a significant need for vision correction.

FIG. 8 SmartLife Lenses are designed for adults whose lens requirements change over time

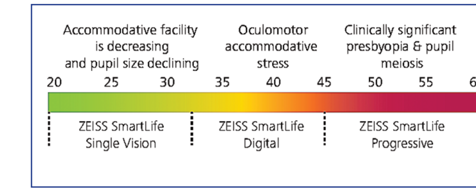
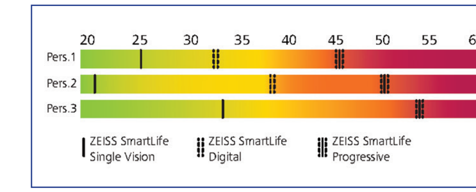


FIG. 9 ZEISS SmartLife Lenses will adapt to the visual history of wearers as they age



In this example, the individual we will call Alexandra has significant ametropia. From the beginning, she will enjoy SmartLife single vision lenses. Over time, her pupils will shrink, and her accommodative amplitude declines, and the stresses of dynamic connectivity will cause symptoms such as digital eyestrain (DES) from accommodative stress. By age 35, she would benefit from SmartLife Digital lenses with the low addition power of +0.50 to +1.25 to reduce accommodative load. Around the age of 45, Alexandra will likely need the full-range afforded by a SmartLife Progressive lens design. Fig. 9 represents a few of the possible stories of other people who will benefit from SmartLife Lenses.

CONCLUSION

In today's connected, on-the-move lifestyle, our visual behavior is dynamic with frequent gaze changes between various directions and distances. Assessing and addressing vision correction must be based on the influence of dynamic connectivity and age-related vision needs on visual behavior. SmartLife lenses help us transition from a single vision lens into a digitally optimized SV lens with a low add power to reduce accommodative stress and finally to a digitally optimized progressive lens.

Sources provided upon request.