Lenses, Devices, Methods and Systems for Refractive Error

Field

Certain disclosed embodiments include lenses, devices and/or methods for changing or controlling the wavefront of light entering an eye, in particular a human eye.

Certain disclosed embodiments are directed to the configuration of lenses, devices, methods and/or systems for correcting or treating refractive errors.

Certain disclosed embodiments are directed to the configuration of lenses, devices, methods and/or systems for addressing refractive errors while provide excellent vision from far to near without significant ghosting.

Certain disclosed embodiments include lenses, devices and/or methods for correcting, treating, mitigating and/or addressing refractive error, in particular in human eyes. The refractive error may for example arise from myopia or hyperopia, with or without astigmatism. The refractive error may arise from presbyopia, either alone or in combination with myopia or hyperopia and with or without astigmatism.

Certain disclosed embodiments of lenses, devices and/or methods include embodiments that address foveal vision; certain embodiments that address both foveal and peripheral vision; and certain other embodiments address peripheral vision.

Exemplary of lenses in the fields of certain embodiments include contact lenses, corneal onlays, corneal inlays, and lenses for intraocular devices (both anterior and posterior chamber).

Exemplary devices in the fields of certain disclosed embodiments include accommodating intraocular lenses and/or electro-active spectacle lenses.

Exemplary methods in the fields of certain embodiments include methods of changing the refractive state and/or wavefront of light entering an eye and received by a retina of the eye (e.g. refractive surgery, corneal ablation), methods of design and/or manufacture of lenses and optical devices, methods of surgery to alter the refractive state of an eye and methods of controlling stimulus for progression of eye growth.

Cross Reference to Related Materials

This application claims priority to Australian Provisional Application No. 2012/901,382, entitled, "Devices and Methods for Refractive Error Control" filed on 5 April 2012, and Australian Provisional Application No. 2012/904,541 entitled Lenses, Devices and Methods for Ocular Refractive Error", 17 October 2012. These Australian Provisional Applications are both incorporated herein by reference in their entirety. In addition, U.S. Patent Nos. 7,077,522 and 7,357,509 are each incorporated herein by reference in their entirety.

Background

For an image to be perceived clearly, the optics of the eye should result in an image that is focussed on the retina. Myopia, commonly known as short-sightedness, is an optical disorder of the eye wherein on-axis images are focussed in front of the fovea of the retina. Hyperopia, commonly known as long-sightedness, is an optical disorder of the eye wherein on-axis images are focussed behind the fovea of the retina. The focussing of images in front of or behind the fovea of the retina creates a lower order aberration of defocus. Another lower order aberration is astigmatism. An eye may also have higher order optical aberrations, including, for example, spherical aberration, coma and/or trefoil. Many people experiencing natural refractive error are progressing (the refractive error is increasing over time). Progression is particularly widespread in people with myopia. Schematic representations of eyes exhibiting myopia or hyperopia and astigmatism are shown in Figures 1A-C respectively. In a myopic eye 100, the parallel incoming beam of light 102 passes the refractive elements of the eye, namely, the cornea 104 and crystalline lens 106, to a focal point 108 short of the retina 110. The image on the retina 110 is therefore blurred. In a hyperopic eye 120, the parallel incoming beam of light 122 passes the refractive elements of the eye, namely, the cornea 124 and crystalline lens 126, to a focal point 128 beyond the retina 130, again rendering the image on the retina 130 blurred. In an astigmatic eye 140, the parallel incoming beam of light 142 passes the refractive elements of the eye, namely, cornea 144 and crystalline lens 146, and results in two foci, namely tangential 148 and sagittal 158 foci. In the example of astigmatism shown in Figure 1C, the tangential focus 148 is in front the retina 160 while the sagittal focus 158 is behind the retina 160. The image on the retina in the astigmatic case is referred to as circle of least confusion 160.

At birth human eyes are generally hyperopic, i.e. the axial length of the eyeball is too short for its optical power. With age, from infancy to adulthood, the eyeball continues to grow until its refractive state stabilizes. Elongation of the eye in a growing human may be controlled by a feedback mechanism, known as the emmetropisation process, so that the position of focus relative to the retina plays a role in controlling the extent of eye growth. Deviation from this process would potentially result in refractive disorders like myopia, hyperopia and/or astigmatism. While there is ongoing research into the cause of deviation of emmetropisation from stabilising at emmetropia, one theory is that optical feedback can provide a part in controlling eye growth. For example, Figure 2 shows cases that would, under a feedback mechanism theory of the emmetropisation process, alter the emmetropisation process. In Figure 2A, the parallel incoming beam of light 202 passes through a negative refractive element 203 and the refractive elements of the eye (the cornea 204 and crystalline lens 206), to form an image at focus point 208, overshooting the retina 210. The resulting image blur on the retina, called hyperopic defocus, is an example of defocus that may encourage eye growth under this feedback mechanism. In contrast, as seen in Figure 2B, the parallel incoming beam of light 252 passes through a positive refractive element 253, the refractive elements of the eye (cornea 254 and crystalline lens 256) to form an image at focus point 258 in front of the retina 260. The resulting image blur, called myopic defocus, on this retina is considered to be an example of defocus induced at the retina that would not encourage eye growth. Therefore, it has been proposed that progression of myopic refractive error can be controlled by positioning of the focus in front of the retina. For an astigmatic system, the spherical equivalent, i.e. the mid-point between the tangential and sagittal foci, may be positioned in front of the retina. These proposals have not however provided a full explanation or solution, particularly in the case of progressing myopia.

A number of optical device designs and refractive surgery methods have been proposed to control the growth of the eye during emmetropisation. Many are generally based on refinements to the idea summarised above that foveal imagery provides a stimulus that controls the growth of the eye. In humans, the eye grows longer during emmetropisation and cannot grow shorter. Accordingly, during emmetropisation an eye may grow longer to correct for hyperopia, but it cannot grow shorter to correct for myopia. Proposals have been made for addressing myopia progression.

In addition to proposed optical strategies to counter the development of refractive error and its progression, in particular myopia, there has also been interest in strategies that involve non-optical intervention like pharmacological substances, such as atropine or pirenzipine.

Another condition of the eye is presbyopia, in which the eye's ability to accommodate is reduced or the eye has lost its ability to accommodate. Presbyopia may be experienced in combination with myopia, hyperopia, astigmatism and higher order aberrations. Different methods, devices and lenses to address presbyopia have been proposed, including in the form of bifocal, multifocal or progressive addition lenses/devices, which simultaneously provide two or more foci to the eye. Common types of lenses used for presbyopia include the following: single vision reading glasses, bifocal or multifocal spectacles; centre-near or centre-distance bifocal and multifocal contact lenses, concentric (ring-type) bifocal contact lenses or multifocal intraocular lenses.

In addition, on occasion it is necessary to remove the crystalline lens of an eye, for example if the person is suffering from cataracts. The removed natural crystalline lens may be replaced by an intraocular lens. Accommodating intraocular lenses allow the eye to control the refractive power of the lens, for example through haptics extending from the lens to the ciliary body.

Masking has been proposed as a way to improve the depth of focus of the eye. However, masking results in loss of light to the eye which is an undesirable quality as it at least deteriorates the contrast of the images cast on the retina. In addition, these features are a challenge to implement on lenses for example, contact and/or intra ocular lenses.

Some problems with existing lenses, devices, methods and/or systems are that, for example, they attempt to correct refractive errors but compromise the quality of the vision at different distances and/or introduce ghosting and/or distortion. Accordingly, what is needed are lenses, devices, methods and/or systems for mitigating and/or addressing refractive errors, for example, myopia, hyperopia or presbyopia, with or without astigmatism, without causing at least one or more of the shortcomings discussed herein. Other solutions will become apparent as discussed herein.

Summary

Certain embodiments are directed to various lenses, devices and/or methods for providing an aberration profile for an eye. Characteristics of aberration profiles and/or methodologies for identifying aberration profiles are described for myopic eyes, hyperopic eyes and/or presbyopic eyes. In addition lenses, devices and methods for an eye with astigmatism are disclosed.

In certain embodiments, a lens for an eye has an optical axis and an aberration profile about its optical axis, the aberration profile having a focal distance and including at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0). The aberration profile provides a retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth; and a RIQ of at least 0.3. The RIQ is Visual Strehl Ratio measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive. In other embodiments the RIQ measure may be different.

In certain embodiments, a lens includes an optical axis and an aberration profile about the optical axis that provides a focal distance for a C(2,0) Zernike coefficient term; a peak Visual Strehl Ratio ('first Visual Strehl Ratio') within a through focus range, and a Visual Strehl Ratio that remains at or above a second Visual Strehl Ratio over the through focus range that includes said focal distance, wherein the Visual Strehl Ratio is measured for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a wavelength selected from within the range 540 nm to 590 nm inclusive, and wherein the first Visual Strehl Ratio is at least 0.35, the second Visual Strehl Ratio is at least 0.10 and the through focus range is at least 1.8 Dioptres.

In certain embodiments, a method for a presbyopic eye includes identifying a wavefront aberration profile for the eye, the wavefront aberration profile including at least two spherical aberration terms. The prescription focal distance of the aberration profile is determined taking into account said spherical aberration and wherein the prescription focal distance is at least +0.25 D relative to a focal distance for a C(2,0) Zernike coefficient term of the wavefront aberration profile. The method may include producing a device, lens and/or corneal profile for the eye to affect said wavefront aberration profile.

In certain embodiments, a method for a myopic eye includes identifying a wavefront aberration profile for the eye and applying or prescribing the aberration profile. The wavefront aberration profile includes at least two spherical aberration terms, wherein the prescription focal distance of the aberration profile is determined taking into account said spherical aberration and wherein the prescription focal distance is at least +0.10 D relative to a focal distance for a C(2,0) Zernike coefficient term of the wavefront aberration profile. The wavefront aberration profile also provides a degrading retinal image quality in the direction posterior to the retina.

Certain embodiments are directed to, a method for a hyperopic eye, the method comprising identifying a wavefront aberration profile for the eye and applying or prescribing the aberration profile. The wavefront aberration profile includes at least two spherical aberration terms, wherein the prescription focal distance of the wavefront aberration profile is determined taking into account said spherical aberration. At the prescription focal distance the wavefront aberration profile provides an improving retinal image quality in the direction posterior to the retina.

In certain embodiments a computational device includes an input to receive first combination of aberrations, one or more processors to compute a second combination of aberrations for one or more optical surfaces, and an output to output the second combination of aberrations, wherein the computed second combination of aberrations provides in combination with the first combination of aberrations a total combination of higher order aberrations (HOA) as disclosed herein. In certain embodiments, the computational device may be used to generate power profiles, aberration profiles, wavefront ablation profiles or combinations thereof. These computations may then be used for contact lenses, corneal inlays, corneal onlays, single and dual element intra-ocular lenses anterior and/or posterior chamber, accommodative intra-ocular lenses, wavefront ablation for corneal refractive surgery techniques and other suitable devices and/or applications.

Further embodiments and or advantages of one or more embodiments will become apparent from the following description, given by way of example and with reference to the accompanying drawings.

Brief description of the drawings

These and other features, aspects, and advantages of the present disclosure will become better understood with regard to the following description, appended claims, and accompanying figures.

Figures 1A-1C are schematic representations of eyes exhibiting myopia, hyperopia and astigmatism respectively.

Figures 2A and 2B are schematic representations respectively of hyperopic defocus and myopic defocus induced at the retina.

Figure 3 shows a two-dimensional through-focus point spread function computed at the retinal plane without higher order aberrations (HOA) and in the presence of HOA of spherical aberration, vertical coma and horizontal trefoil, according to certain embodiments.

Figures 4 to 7 show graphs of the interaction of primary spherical aberration with horizontal coma, vertical coma, horizontal trefoil and vertical trefoil respectively, according to certain embodiments.

Figure 8 shows a graph indicating the magnitude of myopia progression under an optical feedback mechanism for eye growth, for primary spherical aberration vs. primary vertical astigmatism vs. primary horizontal astigmatism, according to certain embodiments.

Figure 9 shows a graph indicating the magnitude of myopia progression for primary spherical aberration vs. secondary vertical astigmatism vs. secondary horizontal astigmatism, according to certain embodiments.

Figure 10 shows a graph indicating the myopia progression on a binary scale for primary spherical aberration vs. secondary spherical aberration, according to certain embodiments.

Figure 11 shows a graph indicating the myopia progression on a binary scale for primary spherical aberration vs. tertiary spherical aberration, according to certain embodiments.

Figure 12 shows a graph indicating the myopia progression on a binary scale for primary spherical aberration vs. quaternary spherical aberration, according to certain embodiments.

Figure 13 shows a graph indicating the myopia progression on a binary scale for primary spherical aberration vs. secondary spherical aberration vs. tertiary spherical aberration, according to certain embodiments.

Figure 14 shows example designs of aberration profiles that provide negative and positive gradient RIQ in a direction of eye growth, according to certain embodiments.

Figure 15 shows a work flow chart for myopic eyes, progressing or non-progressing, according to certain embodiments.

Figure 16 shows a work flow chart for hyperopic eyes, progressing or non-progressing towards emmetropia, according to certain embodiments.

Figures 17 to 25 show example designs of power profiles of correcting lens across the optic zone diameter, for affecting optical feedback mechanisms for myopia, according to certain embodiments.

Figure 26 shows an example design of a power profile of correcting lens across the optic zone diameter, for affecting optical feedback mechanisms for hyperopia, according to certain embodiments.

Figure 27 shows a global through-focus retinal image quality (TFRIQ) for an aberration profile corresponding to a single vision lens.

Figure 28 shows a global TFRIQ for a first aberration profile (Iteration A1), which may have application to a progressing myopic eye.

Figure 29 shows the power profile for a lens for providing the first aberration profile (Iteration A1), according to certain embodiments.

Figure 30 shows a global TFRIQ for a second aberration profile (Iteration A2), which may also have application to a progressing myopic eye, according to certain embodiments.

Figure 31shows the power profile across full chord diameter for a second aberration profile (Iteration A2), according to certain embodiments.

Figures 32 and 33 show a global TFRIQ for a third and fourth aberration profile (Iteration C1 and Iteration C2 represented as power profiles across optic chord diameter in Figures 34 and 35), which may have application to a hyperopic eye, according to certain embodiments.

Figure 36 shows a retinal image quality (RIQ) for seven aberration profiles over a through focus range of 2.5D. The seven aberration profiles correspond to example centre-distance and centre-near aspheric multifocals and concentric ring/annulus type bifocals and three exemplary aberration profiles (Iteration B1, Iteration B2, Iteration B3) obtained after optimising through focus performance, according to certain embodiments.

Figures 37 to 43 show the power profiles of contact lenses across the optic zone diameter, for providing the TFRIQ described in Figure 36, according to certain embodiments.

Figures 44 to 46 show the on-axis TFRIQ for the three exemplary embodiments for presbyopia (Iteration B1, B2 and B3) across four pupil diameters (3 mm to 6 mm) and Figures 47 and 48 show the on-axis TFRIQ for the centre-distance and centre-near concentric designs across four pupil diameters (3 mm to 6 mm) , according to certain embodiments.

Figures 49 and 50 show the on-axis TFRIQ for the centre-distance and centre-near aspheric multifocal designs across four pupil diameters (3 mm to 6 mm) , according to certain embodiments.

Figures 51 and 52 show a monocular correction approach for presbyopia, where different higher order aberration profiles provided for the right and left eyes, by which the through-focus optical and/or visual performance is different in the right and left eye (desired vergences) to provide a combined add power range of 1.5D and 2.5D, on the negative side of through-focus curve, respectively, according to certain embodiments.

Figures 53 and 54 show a monocular correction approach for presbyopia, where different higher order aberration profiles provided for the right and left eyes, by which the through-focus optical and/or visual performance is different in the right and left eye (desired vergences) to provide a combined add power range of 1.5D and 2.5D, on the positive side of through-focus curve, respectively, according to certain embodiments.

Figure 55 shows a global TFRIQ for three further iterations of aberration profile (Iterations A3, A4 and A5 represented in Figure 56, 57 and 58, respectively), for providing a substantially constant retinal image quality across a horizontal visual field from 0 to 30 degrees, according to certain embodiments.

Figures 59 and 60 show example designs of the power profile of correcting contact lenses with opposite phase profiles (Iteration E1 and Iteration E2) and Figures 61 to 63 show the on-axis TFRIQ for Iterations E1 and E2 with three different levels of inherent primary spherical aberration of the candidate eye, according to certain embodiments.

Figure 64 shows the TFRIQ performance measures (depth of focus) of 78 exemplary aberration profiles (Appendix A) that involve a combination of spherical aberration terms. The Y-axis in the graph denotes 'Q' performance metric and X-axis denotes the through-focus range from -1.5 to +1D. In this exemplary, the calculations were performed at 4 mm pupil. The solid black line indicates the through-focus performance of a combination that does not have a mode of spherical aberration while the gray lines indicate the 78 combinations which include at least one higher order spherical aberration term. The 78 combinations were selected with regard to performance on the negative side of the through-focus curve, according to certain embodiments.

Figure 65 shows the TFRIQ performance of one exemplary combination from Figure 56 that involves only positive spherical aberration in comparison with a combination that has no spherical aberration, according to certain embodiments.

Figure 66 shows the TFRIQ performance measures (depth of focus) of 67exemplary aberration profiles that involve a combination of spherical aberration terms (Appendix C). The Y-axis in the graph denotes 'Q' performance metric and X-axis denotes the through-focus range from -1.5 to +1D. In this exemplary, the calculations were performed at 4mm pupil. The solid black line indicates the through-focus performance of a combination that does not have a mode of spherical aberration while the gray lines indicate the 67 combinations which include at least one higher order spherical aberration term. These 67 combinations improve performance on the positive side of the through-focus curve, according to certain embodiments.

Figure 67 shows a work flow chart for presbyopic eyes, according to certain embodiments.

Figure 68 shows a power profile for a toric prescription of a contact lens for both astigmatism and presbyopia, according to certain embodiments.

Figure 69 shows an example lens power profile, which is availed from an exemplary combination of spherical aberration terms and Figure 70 shows the lens power profile converted to an axial thickness profile for a contact lens, according to certain embodiments.

Figure 71 shows an example of axial power profile of lens across a complete chord diameter (Iteration G1), which is one exemplary of design set whose performance is substantially independent of inherent spherical aberration of the candidate eye, according to certain embodiments.

Figure 72 shows the TFRIQ of an exemplary, described as Iteration G1, at 4 mm pupil diameter. Y-axis denotes RIQ performance metric and X-axis denotes through-focus range from -1D to +1.75D. The four different legends, solid black line, solid gray line, dashed black like and, solid double line represent four different levels of spherical aberration in a sample of the affected population at 5 mm pupil diameter, according to certain embodiments.

Figure 73 shows the TFRIQ of an exemplary, described as Iteration G1, at a 5 mm pupil diameter. Y-axis denotes RIQ performance metric and X-axis denotes through-focus range from -1D to +1.75D. The four different legends, solid black line, solid gray line, dashed black like and, solid double line represent four different levels of spherical aberration in a sample of the affected population, at 5 mm pupil diameter, according to certain embodiments.

Figure 74 shows an example of axial power profile of a lens across a half- chord diameter (Iteration J1), which is one exemplary of design set for an intra-ocular lens used to restore vision at distances, encompassing far to near, after removal of the crystalline lens in the eye, according to certain embodiments. Figure 75 shows an example of axial thickness profile of a lens (Iteration J1) across a half- chord diameter, which is one exemplary of design set for an intra-ocular lens used to restore vision at distances, encompassing from far to near, after removal of the crystalline lens in the eye, according to certain embodiments.

Figures 76 show power profiles of eleven different contact lenses across a half-chord diameter, these eleven different designs (Iterations K1 to K11). These are some designs of commercial available lenses.

Figures 77 show power profiles of four different lenses across a half-chord diameter, these four different designs (Iterations R1 to R4) are exemplary of certain embodiments.

Figure 78 show the normalised absolute of amplitude spectrum of a Fast Fourier Transform of eleven different contact lenses (Iterations K1 to K11) as a function of spatial frequency in Cycles/mm. These are the eleven lenses presented in Figure 76.

Figure 79 show the normalised absolute of amplitude spectrum of a Fast Fourier Transform of four different lens designs (Iterations R1 toR4) as a function of spatial frequency in Cycles/mm. These four designs are exemplary of certain embodiments.

Figure 80 show the absolute first derivative of eleven different contact lenses (Iteration K1 to K11) as a function of half-chord diameter (mm). These are the eleven lenses presented in Figure 76.

Figure 81 show the absolute first derivative of four different contact lenses (Iteration R1 to R4) as a function of half-chord diameter (mm). These four designs are exemplary of certain embodiments.

Figure 82 show the average subjective ratings measured on a visual analogue scale for distance vision for a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 83 show the average subjective ratings measured on a visual analogue scale for intermediate vision for a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 84 show the average subjective ratings measured on a visual analogue scale for near vision for a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses

Figure 85 show the average subjective ratings measured on a ghosting analogue scale for distance vision for a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 86 show the average subjective ratings measured on a ghosting analogue scale for near vision for a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 87 show the average subjective ratings measured on a visual analogue scale for overall vision for a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 88 show the average subjective ratings measured on a lack of ghosting analogue scale for distance vision for a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 89 show the average subjective ratings measured on a lack of ghosting analogue scale for near vision for a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 90 show the average subjective ratings measured on a ghosting analogue scale for distance and near vision combined for a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 91 show the average subjective ratings measured on a visual analogue scale for cumulative performance of vision including distance, intermediate, near vision and lack of ghosting at distance and near for a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 92 shows the percentage of people whose subjective rating score on a visual analogue scale was greater than 9, for distance vision. The data were obtained from a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 93 shows the percentage of people whose subjective rating score on a visual analogue scale was greater than 9, for intermediate vision. The data were obtained from a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 94 shows the percentage of people whose subjective rating score on a visual analogue scale was greater than 9, for near vision. The data were obtained from a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 95 shows the percentage of people whose subjective rating score on a visual analogue scale was greater than 9, for overall vision. The data were obtained from a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 96 shows the percentage of people whose subjective rating score on a ghosting analogue scale was greater than 3, for distance vision. The data were obtained from a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 97 shows the percentage of people whose subjective rating score on a ghosting analogue scale was greater than 3, for near vision. The data were obtained from a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 98 shows the percentage of people whose subjective rating score on a visual analogue scale was greater than 9, for cumulative vision. The cumulative vision rating was obtained by averaging the distance, intermediate, near, overall vision ratings, also including lack of ghosting for distance and near. The data were obtained from a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 99 shows the average objective measures of high-contrast visual acuity on a sample of an affected presbyopic population. The measures were obtained using a test distance of 6 metres and presented in log MAR scale. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 100 shows the average objective measures of contrast sensitivity on a sample of an affected presbyopic population. The measures were obtained using a test distance of 6 metres and presented in log scale. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 101 shows the average objective measures of low-contrast visual acuity on a sample of an affected presbyopic population. The measures were obtained using a test distance of 6 metres and presented in log MAR scale. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 102 shows the average objective measures of intermediate visual acuity on a sample of an affected presbyopic population, using a test distance of 70 centimetres. The measures are presented in log MAR scale. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 103 shows the average objective measures of near visual acuity on a sample of an affected presbyopic population, using a test distance of 50 centimetres. The measures are presented in log MAR scale. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 104 shows the average objective measures of near visual acuity on a sample of an affected presbyopic population, using a test distance of 40 centimetres. The measures are presented in log MAR scale. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 105 shows the average objective measures of combined visual acuity on a sample of an affected presbyopic population. The combined visual acuity includes measures at distance, intermediate and near at 50 cm. The measures are presented in log MAR scale. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 106 shows the average objective measures of combined visual acuity on a sample of an affected presbyopic population. The combined visual acuity includes measures at distance, intermediate, near at 50 cm and near at 50 cm. The measures are presented in log MAR scale. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 107 shows the percentage of people whose subjective rating score on a visual analogue scale was equal to 1, for ghosting at distance or near. The data were obtained from a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Figure 108 shows the percentage of people whose subjective rating score on a visual analogue scale was less than 2, for ghosting at distance and near. The data were obtained from a sample of an affected presbyopic population. Four of the lenses H to K are exemplary of certain embodiments, while lenses A to G are commercial lenses.

Detailed Description

The present disclosure will now be described in detail with reference to one or more embodiments, some examples of which are illustrated and/or supported in the accompanying figures. The examples and embodiments are provided by way of explanation and are not to be taken as limiting to the scope of the disclosure.

Furthermore, features illustrated or described as part of one embodiment may be used by themselves to provide other embodiments and features illustrated or described as part of one embodiment may be used with one or more other embodiments to provide a further embodiments. It will be understood that the present disclosure will cover these variations and embodiments as well as other variations and/or modifications.

It will be understood that the term "comprise" and any of its derivatives (e.g., comprises, comprising) as used in this specification is to be taken to be inclusive of features to which it refers, and is not meant to exclude the presence of any additional features unless otherwise stated or implied. The features disclosed in this specification (including accompanying claims, abstract, and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise.

The subject headings used in the detailed description are included only for the ease of reference of the reader and should not be used to limit the subject matter found throughout the disclosure or the claims. The subject headings should not be used in construing the scope of the claims or the claim limitations.

The optical and/or visual performance of the human eye may be limited by one or more optical and/or visual factors. Some of the factors may include monochromatic and polychromatic optical wavefront aberrations and the retinal sampling which may impose a Nyquist limit on spatial vision. Some other factors may include the Stiles-Crawford effect and/or scattering. These factors or combinations of these factors may be used to determine retinal image quality (RIQ), according to certain embodiments. For example, retinal image quality (RIQ) may be obtained by measuring wavefront aberrations of the eye with or without a correcting lens in place using appropriate adjustments using factors such factors as Stiles Crawford effect if required. As disclosed herein, various ways of determining RIQ may also be used such as, but not limited to, a simple Strehl ratio, point spread function, modulation transfer function, compound modulation transfer function, phase transfer function, optical transfer function, Strehl ratio in spatial domain, Strehl ratio in Fourier domain, or combinations thereof.

Section 1: Retinal image quality (RIQ)

With use of a wavefront aberrometer, such as a Hartmann-Shack instrument, the optical characteristics of a candidate eye with or without refractive correction, model eye with or without refractive correction can be measured so as to identify a measure of retinal image quality (RIQ). In some examples, the model eye used may be a physical model that is anatomically, optically equivalent to an average human eye. In certain examples, the RIQ can be calculated via optical calculations like ray-tracing and/or Fourier optics. Several measures of RIQ are described herein.

(A) Strehl Ratio

Once the wavefront aberration of the candidate eye is availed, the image quality at the retina of the eye can be determined by computing the simple Strehl ratio, as described in the Equation 1. In certain applications, the image quality at the retina of the eye may be characterised by calculating a simple Strehl ratio as illustrated in Equation 1. The Strehl ratio can be computed in both spatial domain (i.e. using Point spread function) and in Fourier domain (i.e. using Optical transfer function as shown below in equation 1). The Strehl ratio measure is bound between 0 and 1, where 1 is associated with best achievable image quality.

$$\boldsymbol{Strehl's\,ratio} = \frac{\iint_{-\infty}^{+\infty}(FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}|^2))}{\iint_{-\infty}^{+\infty}(FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}|^2))}$$

Equation 1

(B) Visual Strehl Ratio

U.S. Patent 7,077,522 B2 describes a vision metric called the sharpness metric. This metric can be computed by convolving a point spread function with a neural quality function. Further, U.S. Patent 7,357,509 describes several other metrics to gauge optical performance of the human eye. One such RIQ measure is the Visual Strehl Ratio, which is calculated in the frequency domain. In certain applications, the RIQ measure is characterised by Visual Strehl Ratio which is calculated in the frequency domain. The Visual Strehl Ratio in the frequency domain is described by Equation 2 and is bound between 0 and 1, where 1 is associated with best achievable image quality at the retina. This metric addresses monochromatic aberrations.

$$\boldsymbol{monochromatic\ RIQ} = \frac{\iint_{-\infty}^{+\infty} CSF(f_x,f_y) * real(FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}|^2))}{\iint_{-\infty}^{+\infty} CSF(f_x,f_y) * (FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}|^2))}$$

Equation 2

The RIQ measure of monochromatic Visual Strehl Ratio shows high correlation with objective and subjective visual acuity. This measure may be used to describe RIQ in certain disclosed embodiments. However, other measures described herein and alternatives thereto may be used in the design of optical devices, lenses and/or methods.

(C) Polychromatic RIQ

The Visual Strehl Ratio defined by Williams, discussed above, addresses monochromatic light. To accommodate for polychromatic light, a metric called the polychromatic retinal image quality (polychromatic RIQ) is defined that includes chromatic aberrations weighed with spectral sensitivities for selected wavelengths. The polychromatic RIQ measure is defined in Equation 3. In certain applications, the polychromatic RIQ measure is characterised by Equation 3.

polychromatic RIQ

$$= \frac{\iint_{-\infty}^{+\infty} CSF(f_x, f_y) * \sum_{\lambda min}^{\lambda max} (S(\lambda) * (real(FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}|^2))))}{\iint_{-\infty}^{+\infty} CSF(f_x, f_y) * \sum_{\lambda min}^{\lambda max} (S(\lambda) * ((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}|^2))))}$$

Equation 3

(D) Monochromatic Global RIQ

The Visual Strehl Ratio or monochromatic RIQ discussed herein and in sub-section B primarily addresses on-axis vision. As used herein, unless the context clearly requires otherwise, 'on-axis' is a reference to one or more of the optical, visual or papillary axis. To accommodate for wide angle view (i.e. peripheral visual field), a metric called the global retinal image quality (GRIQ) is defined that includes range of visual field eccentricities. A monochromatic GRIQ measure is defined in Equation 4. In certain applications, the monochromatic GRIQ measure is characterised by Equation 4.

monchromatic Global RIQ

$$= \frac{\int_{\alpha min}^{\alpha max} \int_{\varphi min}^{\varphi max} \left[\iint_{-\infty}^{+\infty} CSF(f_x, f_y) * real(FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}|^2))\right] d\varphi\, d\lambda}{\int_{\alpha min}^{\alpha max} \int_{\varphi min}^{\varphi max} \left\{\iint_{-\infty}^{+\infty} CSF(f_x, f_y) * (FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}|^2))\right\} d\varphi\, d\lambda}$$

Equation 4

(E) Polychromatic Global RIQ

One other form of RIQ metric that accommodates for polychromatic light and wide angle view (i.e. peripheral visual field), a metric is called the polychromatic global retinal image quality (GRIQ) is defined that includes chromatic aberrations weighed with spectral sensitivities

for selected wavelengths and range of visual field eccentricities. A polychromatic GRIQ measure is defined in Equation 5. In certain applications, the polychromatic GRIQ measure is characterised by Equation 5.

polychromatic Global RIQ

$$= \frac{\int_{\alpha min}^{\alpha max} \int_{\varphi min}^{\varphi max} \left\{ \iint_{-\infty}^{+\infty} CSF(f_x, f_y) * \sum_{\lambda min}^{\lambda max} (S(\lambda) * (real(FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}|^2)))) \right\} d\varphi\, d\lambda}{\int_{\alpha min}^{\alpha max} \int_{\varphi min}^{\varphi max} \left\{ \iint_{-\infty}^{+\infty} CSF(f_x, f_y) * \sum_{\lambda min}^{\lambda max} (S(\lambda) * ((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}|^2)))) \right\} d\varphi\, d\lambda}$$

Equation 5

In Equations 1 to 5:

f specifies the tested spatial frequency, this can be in the range of F_{min} to F_{max} (denoting the boundary limits on the spatial frequency content), for example $F_{min} = 0$ cycles/degree; $F_{max} = 30$ cycles/degree;

f_x and f_y specifies the tested spatial frequency in x and y directions;

CSF (f_x, f_y) denotes a contrast sensitivity function, which in a symmetric form can be defined as CSF (F) = 2.6(0.0192+0.114*f)* $\exp^{-(0.114*f)\wedge 1.1}$;

FT denotes, in one form of the equation, a 2D fast Fourier transform;

A(ρ, θ) and W(ρ, θ) denotes pupil diameter & wavefront phase of the test case, respectively;

Wdiff (ρ, θ) denotes wavefront phase of the diffraction limited case;

ρ and θ are normalised polar coordinates, where ρ represents the radial coordinate and θ represents the angular coordinate or the azimuth;

λ denotes wavelength;

α denotes field angle;

φ denotes the meridian angle;

S (λ) denotes spectral sensitivity.

The wavefront phase, for example, can be written as a function set of standard Zernike polynomials up to a desired order, as described below,

$$W(\rho,\theta) = \sum_{i=1}^{k} a_i Z_i(\rho,\theta)$$

Where, a_i denotes the ith coefficient of Zernike polynomial

$Z_i(\rho,\theta)$, denotes the ith Zernike polynomial term

'k', represents the highest term of the expansion

These polynomials can be represented in the Optical Society of America format or Malacara format or other available Zernike polynomial expansion formats. Apart from the Zernike method of constructing the wavefront phase, other non-Zernike methods of wavefront phase construction may also be adopted, i.e., Fourier expansion, Taylor expansion, etc.

(F) Global RIQ metric integrated myopic impetus exposure time

The factors discussed herein with regard to RIQ variants include one or more of the following: wavefront aberration, chromaticity and spectral sensitivity, Stiles-Crawford effect of the first kind, and optical and/or visual performance in the peripheral retina. Another factor that may be included is the amount of time spent at various accommodative states on an average day (the daily amount of near work), also known as the myopic impetus exposure time, T (A). This provides the following GRIQ variant:

$$\int_{Amin}^{Amax} T(A) * GRIQ(dA)$$

Equation 6

(G) Other possible RIQ measures

As discussed herein, other measures of RIQ may also be used in the design of devices, lenses and/or methods. One example of an alternative RIQ measure is simple modulation transfer function (MTF). Referring to Equation 2, a polychromatic MTF is formed by computing the modulus of real part of the optical transfer function and in addition excluding the step of convolution with the CSF function. A monochromatic MTF is formed if S (λ) is also removed from Equation 2.

Section 2: Through focus RIQ

RIQ may also be considered anterior and/or posterior to the retina. The RIQ anterior

and/or posterior to the retina is called 'through focus RIQ' herein and abbreviated as TFRIQ herein. Similarly, RIQ at and/or around the retina may also be considered over a range of focal lengths (i.e., when the eye accommodates, which causes changes in refractive characteristics of the eye in addition to the focal length to change). Certain embodiments may consider not only RIQ at the retina, but also the change in through focus RIQ. This is in contrast to an approach that may, for example, consider only the RIQ at the retina and/or an integral or summation of RIQ measures at or around the retina. For example, certain embodiments of the lenses, devices and/or methods disclosed herein effect, or are designed to effect for an eye with particular refractive characteristics, a change in or control over the extent or rate of change in RIQ in the directions anterior to the retina (i.e., the direction from the retina towards the cornea) and/or posterior to the retina. Certain embodiments may also effect, or are designed to effect, a change in or control over the variation in RIQ with focal distance. For example several candidate lens designs may be identified through effecting a change in the RIQ in the direction posterior to the retina and then a single design or subset of designs may be identified taking account of variation in RIQ with change in focal length. In certain embodiments, the process described above is reversed. In particular, a set of designs is selected based on changes in RIQ at the retina with focal distance. Selection within the set is then made with reference to the TFRIQ. In certain embodiments, a single evaluation process is conducted that combines consideration of TFRIQ and changes of RIQ at the retina with the focal distance. For example, an average measure of RIQ with changes in focal distance may be used to identify a design. The average measure may give more weight to particular focal distances (e.g. distance vision, intermediate vision and near vision and therefore may be weighted differently).

In certain embodiments, through focus and/or changes of RIQ at the retina with focal distance are considered for one or more of the following: i) on-axis, ii) integrated around on-axis, for example in an area corresponding to or approximating a pupil size, with or without consideration of the Stiles-Crawford effect, iii) off-axis (where off-axis means a location, set of locations and/or integral of locations on the retina outside the fovea, which may be where light at field angles more than about 10 degrees is focussed), and iv) one or more combinations of i) to iii). In certain applications, the field angles are about 15 or more, 20 or more, 25 or more or 30 or more degrees.

While the description herein refers to quantitative measures of RIQ, qualitative measures may also be used to assist the design process of an aberration profile in addition to the

quantitative measures. For example, the Visual Strehl Ratio at a particular through focus location is computed or determined based on the point spread function. As can be seen from the example images referred to in the following section, the point spread function can be visually evaluated. This provides for a method of qualitatively evaluating through focus.

Section 3: Aberrations affecting image quality at the retina and TFRIQ

The influence of lower order aberrations on RIQ and TFRIQ is known in the art. The use of corrective lower order aberrations represents a traditional method of refractive error correction for an eye. Accordingly, the identification of an aberration profile consisting of lower order aberrations to correct for defocus and astigmatism will not be described herein in detail.

The influence of higher order aberrations (HOA) on image quality is demonstrated in Figure 3 from the through-focus two-dimensional point spread functions (300). In Figure 3 the rows show the point spread functions for a selection of aberrations and the horizontal axis shows the extent of defocus for the relevant aberration, in Dioptres.

Exemplary HOA on image quality are illustrated in Figure 3, according to certain embodiments. This is illustrated by the through-focus two-dimensional point spread functions 300 illustrated in Figure 3. In Figure 3, the rows show the point spread functions for a selection of aberrations and the horizontal axis shows the extent of defocus for the certain relevant aberration, in Dioptres.

The point spread functions without higher order aberrations 302 (in the illustrated example images at the retina in an eye with myopia or hyperopia alone), with vertical coma 306 alone, and with horizontal trefoil 308 alone, remain symmetrical with positive and negative defocus. With positive and negative primary spherical aberrations, either alone 304 or in combination 310 with coma and/or trefoil, the through-focus in the point spread function is asymmetrical for positive and negative defocus. With certain HOA positive and negative defocus has unequal effects on the image quality. It can be seen that these unequal effects are more pronounced for spherical aberrations. The HOA that exhibit asymmetrical effects on RIQ, visual acuity and/or contrast sensitivity have application certain of the lenses, devices and/or methods disclosed herein.

The interactions occurring between HOA and defocus influence the TFRIQ. Some HOA interact favourably with defocus to improve RIQ, while others interact unfavourably to cause RIQ degradation. The most commonly measured higher order ocular aberrations include spherical aberration, coma and trefoil. Apart from these, the HOA profiles obtained with some multifocal optical designs precipitate considerable magnitudes of wavefront aberrations, often expressed up to the 10th order in Zernike polynomial representation.

In general terms, in the Zernike pyramid, the terms closer to the centre are often more influential, or useful, when gauged in terms of the resultant optical effects than those at the edge/corner. This may be because the terms farther away from the centre have a relatively large planar area on the wavefront compared to those whose angular frequency is closer to zero. In certain applications, Zernike terms that have the highest potential, or substantially greater potential, to interact with defocus are, for example, the terms with even radial order having zero angular frequency component, i.e., the fourth, sixth, eighth, and tenth order Zernike coefficients, representing primary, secondary, tertiary and quaternary, spherical aberrations. Other Zernike coefficients representing other order of spherical aberration may also be used.

The foregoing description of aberrations identifies some of the aberrations that affect retinal RIQ and through focus RIQ. The description is not, nor is it intended to be, an exhaustive description of the various aberrations that affect retinal RIQ and through focus RIQ. In various embodiments, additional aberrations that affect the retinal RIQ and/or through focus RIQ may be considered, the relevant aberrations being identified having regard to the current refractive state of the ocular system (meaning the eye together with lenses or optical devices that affect the wavefront received by the retina) and a target retinal RIQ/through focus RIQ.

Section 4: Optimising RIQ

When designing and/or selecting a required change in refractive state of an eye, a measure of RIQ and through focus RIQ is typically performed for certain disclosed embodiments. In particular, finding a magnitude and sign of defocus that interacts with one or more of the relevant aberrations and produce an acceptable RIQ and through focus RIQ is typically performed. The search is performed for the best or at least an acceptable combination of RIQ and through focus RIQ. In certain embodiments, the selected combination is determined by evaluating the RIQ and the through focus RIQ and selecting the combination that is suitable,

substantially optimised, or optimised for the application. In certain embodiments described herein, a merit function S=1/RIQ is used for this purpose. In certain embodiments, the approximation of a merit function S = 1/RIQ may be used for this purpose.

Identifying aberration coefficients that optimise, or substantially optimise, RIQ at the retina may be achieved, in certain embodiments; by finding a minimum, or substantially minimum, value of the function S. Considering the RIQ optimisation routine over a range of dioptric distances (through-focus) adds complexity to the optimisation process. Various methods can be used to address this complexity.

One example is to use a non-linear, unconstrained optimization routine, over the chosen group of Zernike SA coefficients as variables, according to certain embodiments. A random element, either automatic and/or through human intervention may be incorporated to shift to different locations so as to find alternative local minima of the function S. The criteria by which the optimisation routine evaluates performance may be a combination of retinal RIQ and keeping the through focus RIQ within predefined bounds of the retinal RIQ. The bounds may be defined in various ways, for example as a range about the value for retinal RIQ. The range may be fixed (e.g. plus or minus 0.15 for Visual Strehl ratio or similar measure), or may vary (e.g. be within a defined rate of change with increasing distance from the retina). In certain embodiments, the range may be fixed to one or more of the following ranges: plus or minus 0.05, or plus or minus 0.1 or plus or minus 0.15. These ranges may be used with one or more of the following: a simple Strehl ratio, point spread function, modulation transfer function, phase transfer function, optical transfer function, Strehl ratio in Fourier domain, or combinations thereof.

As explained in more detail herein, the goal function for TFRIQ may change depending on whether the objective of the merit function is to provide a TFRIQ with a slope that provides stimulus either to inhibit or to encourage eye growth of the candidate eye, under an optical feedback explanation of emmetropisation, at least in certain embodiments. In certain other applications, for example correction to ameliorate presbyopia, the objective of the merit function is to provide a TFRIQ with an acceptable low slope in magnitude or a slope that substantially equal to zero. In certain other presbyopic embodiments, a slope with acceptably low in magnitude for TFRIQ may be considered from one or more of the following: a) slope of TFRIQ about zero, b) slope of TFRIQ equal to zero, c) slope of TFRIQ greater than zero and less than 0.25 per dioptre, d) slope of TFRIQ greater than -0.25 and less than zero per dioptre, e) slope of TFRIQ greater than zero and less than 0.5 per dioptre or f) slope of TFRIQ greater than -0.5 and

less than zero per dioptre.

Another approach is to limit the number of possible combinations of aberration profiles. One way of limiting the possible aberration values is to specify that the Zernike coefficients can only have values corresponding to increments of 0.05 μm focus, or another increment interval. In certain embodiments, the Zernike coefficients may have values corresponding to increments of about 0.01μm, about 0.02μm, about 0.03μm, about 0.04μm or about 0.05μm. In certain embodiments, the Zernike coefficients may have values corresponding to increments of 0.01μm, 0.02μm, 0.03μm, 0.04μm or 0.05μm. In certain embodiments, the Zernike coefficients may have values corresponding to from increments selected within one or more following ranges: 0.005μm to 0.01μm, 0.01μm to 0.02μm, 0.02μm to 0.03μm, 0.03μm to 0.04μm, 0.04μm to 0.05μm, or 0.005μm to 0.05μm. The interval can be selected having regard to the available computational resources. By limiting the number of allowable coefficient values it is possible to simulate the performance of a substantial portion of the aberration profiles formed by the combinations of Zernike coefficients, following which those with the best or acceptable on-axis RIQ and through focus RIQ can be identified. The results of this process may be used to constrain more fine-tuned analysis, for example by returning to an optimisation routine with coefficient values within a small range around an identified candidate combination of higher order aberrations.

Section 5: Controlling stimulus for emmetropisation by optical feedback

A person may be identified as being at risk of developing myopia based on, for example, one or more of the following indicators, including whether their parents experienced myopia and/or myopia, their ethnicity, lifestyle factors, environmental factors, amount of near work, etc. Other indications or combinations of indicators may also be used, according to certain embodiments. For example, a person may be identified as being at risk of developing myopia if their eye and/or eyes have a RIQ at the retina that improves in the direction of eye growth. The RIQ can be obtained either with or without refractive correction that is currently in use (for example: with or without a current prescription of spectacle or contact lens). In certain embodiments, the use of improving RIQ in the direction of eye growth may be used alone or in conjunction with one or more other indicators, for example the other indicators listed herein.

From one perspective, the emmetropisation process can be explained under an optical feedback mechanism that is based on RIQ at the retina and/or the slope of TFRIQ in the anterior-

posterior direction to the retina. According to this perspective on emmetropisation, the candidate eye is stimulated to grow to the position where the merit function S of the optimisation routine is minimised or substantially minimised. Under this explanation of emmetropisation process, at least for human eyes, if the location of a local, or the global minimum of the merit function S, then the eye may be stimulated to grow longer, in certain embodiments. In yet another application, the substantial minimum of the merit function optimisation routine may be a local minimum or global minimum. In other applications, if the location of a local or the global minimum of the merit function S is posterior to the retina or if through focus RIQ improves posterior to the retina, then the eye may be stimulated to grow longer. For example, if the location of a local or the global minimum of the merit function S is located on the retina or anterior to the retina, then the eye may remain at the same length.

The following description herein describes how combinations of selected HOA can affect a change in through focus RIQ. These aberrations can readily be incorporated into a lens, optical device and/or used in a method of changing the aberration profile of the wavefront of the incoming light received by the retina.

In certain embodiments, characterizations of these aberrations can readily be incorporated into a lens, optical device and/or used in a method of changing the aberration profile of the wavefront of the incoming light received by the retina. This provides a mechanism by which certain embodiments may change the refractive state of a candidate eye. In certain embodiments, the lens, optical device and/or method will at least include the aberration characteristics of the embodiments to alter the refractive state of a candidate eye.

As described in more detail herein, achieving a target TFRIQ is considered together with achieving or obtaining substantially closer to a target on-axis RIQ at the retina for a particular focal length, which is typically distance vision, in certain embodiments, In certain applications, one or more of the following are referred as distance vision is objects greater than 6 metres. In other applications, a target TFRIQ may be considered for another focal length alternative to distance vision, for example intermediate vision or near vision. In some applications, intermediate vision may be defined as the range from about 0.5 to 6 metres. In some applications, near vision may be defined as the range from 0.3 to 0.5 metres.

For the examples described herein the RIQ was evaluated, or characterised by, using the Visual Strehl Ratio shown in Equation 2.

(A) Primary spherical aberration, coma and trefoil

The interactions between primary spherical aberration, coma and trefoil and their affect on eye growth can be described, or characterised by, using a wavefront phase function defined using defocus, primary spherical aberration (PSA), coma and trefoil terms of a standard Zernike expansion. Other ways are also possible.

The pupil size was fixed at 4 mm and the calculations were performed at 589nm wavelength. For the purposes of evaluating affects of aberration profiles on ocular growth, it was assumed that a location of a minimum of the above described function S posterior to the retina provides a stimulus to grow to that location and that there will not be stimulus for eye growth if the minimum of the function S is on or in front of the retina. In other words, it is assumed that the image formed on the retina provides a stimulus to grow to minimise the function S. The range of values of PSA, horizontal and vertical coma, and horizontal and vertical trefoil that were used in the simulations are:

PSA	= (-0.30, -0.15, 0.00, 0.15, 0.30) μm
Horizontal Coma	= (-0.30, -0.15, 0.00, 0.15, 0.30) μm
Vertical Coma	= (-0.30, -0.15, 0.00, 0.15, 0.30) μm
Horizontal Trefoil	= (-0.30, -0.15, 0.00, 0.15, 0.30) μm and
Vertical Trefoil	= (-0.30, -0.15, 0.00, 0.15, 0.30) μm.

With a total of 3125 combinations tested, overall it was observed that spherical aberration primarily governed the direction of improving RIQ.

Figures 4 to 7 illustrate the stimulus for eye growth resulting from TFRIQ for a selection of the combinations, in particular the combined effects of PSA together with horizontal and vertical coma, and together with horizontal and vertical trefoil, in accordance with certain embodiments. Figures 4 to 7 are on a continuous scale and white (0) indicates no progression and gray-to-black transition indicates the amount of progression in Dioptres.

Figure 4 shows a graph 400 of the interaction of primary spherical aberration and horizontal coma. The gray plot indicates the amount of progression of myopia that is stimulated by the combination of these two aberrations, where white 402 indicates no stimulus for progression and shades towards black 404 indicate stimulus for progression of myopia (in this case up to -0.8 D) as a result of PSA combined with horizontal coma. Figure 5 shows a graph

500 of myopia progression as a function of the interaction of primary spherical aberration and vertical coma. Like in Figure 4, white areas 502 indicate no stimulus for progression and dark areas 504 indicate stimulus for progression. Figure 6 shows a graph 600 of the interaction of primary spherical aberration and horizontal trefoil. Figure 7 shows a graph 700 of myopia progression as a function of the interaction of primary spherical aberration and vertical trefoil. For the combinations shown in Figures 4 to 7, about 52% of the combinations provide stimulus to encourage eye growth.

Stimulus for eye growth may accordingly be removed by controlling the refractive state of an eye to be within one or more of the white areas in Figures 4 to 7. This may be achieved, for example, by designing a lens or optical device that when applied modifies the refractive characteristics of the eye, to result in the retina of the eye experiencing a through focus RIQ that does not substantially improve, or does not improve, in the direction of eye growth (posterior to the retina) or which decreases in the direction of eye growth.

Although trefoil and coma in the range of -0.30 to 0.30μm over a 4 mm pupil do not appear to have a significant impact on the direction of growth (the maximum progression effect is only -0.1D), positive PSA seems to accelerate growth while negative PSA seems to inhibit growth. The PSA therefore appears to have the dominant effect. Accordingly, at least for an eye with positive PSA and optionally one of coma and trefoil, adding negative PSA may inhibit eye growth under the optical feedback explanation of emmetropisation. It follows that providing negative PSA to an eye, or at least removing positive PSA may remove the stimulus for eye growth. The coma and trefoil in the eye may be left unchanged or optionally partially or fully corrected (preferably within the range of -0.30 to 0.30 μm).

(B) Spherical aberration and astigmatism

To illustrate the interactions between primary spherical aberration and astigmatism, a wavefront phase function was defined using these aberrations (including both horizontal/vertical and oblique components) and defocus. Figures 8 to 13 (unlike Figures 4 to 7) are on a binary scale - where white (1) indicates test cases that cause stimulus for progression (i.e. increase in ocular growth) and black (0) indicates candidate combinations that result in no progression or very little progression (i.e., no ocular growth stimulus or a stop signal). The scale has no units. Figures 8 to 13 illustrate certain disclosed embodiments.

Figure 8 is an exemplary that shows a graph 800 indicating the magnitude of myopia progression for PSA vs. a primary oblique astigmatic component (POA) vs. a primary horizontal/vertical astigmatic (PHV) component. In this example, the graph 800 indicates those combinations of PSA and astigmatism that may result in stimulus for myopia progression (white) and those combinations that will not result in stimulus for myopia progression (black). Neither POA nor PHV appear to have a significant impact on the effects of PSA.

Figure 9 is an exemplary shows a graph 900 indicating the magnitude of myopia progression for PSA vs. a secondary oblique astigmatic (SOA) component vs. a secondary horizontal/vertical astigmatic (SHV) component, according to certain embodiments. In this example, neither SOA nor SHV appear to have a significant impact on the effects of PSA.

A stimulus for eye growth may accordingly be removed by controlling the refractive state of an eye to be within one or more of the white areas in Figures 8 and 9.

From Figures 8 and 9, is an exemplary, the primary and secondary astigmatic components seem to have, or have, a small influence on enhancing or inhibiting eye growth, when combined with PSA. Accordingly, considering these aberrations, this indicates priority may be provided to PSA. In addition, it may be determined whether the eye has high levels of POA, PHV, SOA and/or SHV. If this is the case, in this example, then correcting these aberrations (by reducing or substantially eliminating them) may also assist in removing stimulus for eye growth.

(C) Higher order spherical aberrations

For unaided or single-vision spectacle corrected eyes a fourth order Zernike expansion may be used to describe, or characterise, the wavefront at the exit pupil. However, this may not not necessarily the case when, for example, contact lenses are used for correction, especially with multifocal contact lenses (both aspheric and concentric), substantial amounts of fifth order and higher HOA may be used.. Multifocal contact lenses may, for example, be described using up to about the tenth or twentieth order of Zernike polynomials. In such cases the magnitudes and signs of the higher order spherical aberrations start to play a significant role (in addition to PSA).

To illustrate the interactions between primary, secondary, tertiary and/or quaternary spherical aberrations of a standard Zernike expansion, a wavefront phase was defined using these terms and defocus. Several combinations of HOA as predicted from modelled data with such

multifocal contact lenses were used. Selective sets of these HOA that demonstrate interactions to produce peak RIQ were obtained via dedicated non-linear optimization routines. The calculations were performed over a 4 mm pupil, and at 589nm wavelength. It was observed that at least the first three modes of spherical aberration of the inherent eye played a role in governing the direction of stimulus for eye growth and in some cases higher modes of spherical aberration also played a role. In certain applications, these roles were significant.

The results described below relate to secondary spherical aberration (SSA), tertiary spherical aberration (TSA) and quaternary spherical aberration (QSA), but spherical aberrations with higher orders may also be used in embodiments of the lenses, devices and/or methods described herein.

For four types of spherical aberrations, a range from -0.30 to 0.30 μm was used to investigate the effects of the combinations of HOA. These ranges for these types of aberrations do not necessarily accord with normative distributions of aberrations associated with eyes because the occurrence of these higher order aberrations are not necessarily associated with the eyes but with the optical devices (such as multifocal contact lenses) alone or in combination with the eyes. Furthermore, the range from -0.30 to 0.30 μm is merely used to illustrate the effects, but when determining combinations of HOA to provide an aberration profile in a lens or optical device, or to be effected by surgical procedures, larger or smaller ranges may be used.

Figures 10 to 12 are exemplary that show the stimulus for myopia progression as a function of PSA together with SSA, TSA and QSA respectively, according to certain embodiments. In this example, this schema is a binary colour plot, where white (0) indicates wavefront aberration combinations that provide stimulus for myopia progression under the feedback mechanism described herein and black (1) indicates combinations that discourage myopia progression. From these graphs it is apparent that the higher orders of spherical aberrations have an impact on the stimulus for progression of myopia. In this example, about 82% of the combinations investigated suggest stimulus for eye growth. Interactions of the spherical aberration terms depend on their individual signs and then their individual magnitudes.

Figure 10 is an exemplary that shows a graph 1000 indicating the presence of stimulus for myopia progression as a function of combinations of PSA and SSA, according to certain embodiments. In Figure 10, it can be seen that when PSA in the range -0.30 μm to 0.20 μm is combined with negative SSA ranging from 0.00 to -0.30 μm, there is little or no improvement of RIQ in the direction of eye growth, thus no myopia progression is predicted (i.e. in the area

indicated 1004). However, when PSA ranging from 0.20 to 0.30 μm is considered with negative SSA of about -0.10 μm, it seems to aggravate the progression, as indicated in the area 1002. Overall, the sign of SSA seems to have a governing effect on the effect of the wavefront aberrations and the resultant retinal image quality. In this example, negative SSA of considerable magnitudes (i.e. greater than -0.20 μm) predicts a protective effect against myopia progression when combined with either positive or negative PSA, when PSA and SSA are the only two HOA involved in the wavefront aberration of the candidate eye.

Figure 11 is an exemplary that shows a graph 1100 indicating the presence of stimulus for myopia progression as a function of combinations of PSA and TSA, according to certain embodiments. When PSA and TSA have the same sign and TSA is about 4/5th of PSA in magnitude, as indicated by rectangular box 1106, no or little myopia progression is predicted (black area). However, in this example, with other combinations of PSA and TSA, for example as indicated in areas 1102 and 1104, myopia progression can be expected.

Figure 12 is an exemplary that shows a graph 1200 indicating the presence of stimulus for myopia progression as a function of combinations of PSA and QSA, according to certain embodiments. In this example, when PSA and QSA have opposite signs and QSA is about 4/5th of PSA in magnitude, as indicated by the predominantly black area 1204, no myopia progression is predicted. However, with other combinations of PSA and QSA, (for example as indicated in white areas 1202 and 1206) myopia progression can be expected.

Figure 13 is an exemplary that is a graph (1300) showing the presence of stimulus for progression of myopia as a function of PSA, SSA and TSA, according to certain embodiments. This schema is a binary colour plot, where 1 (white) indicates wavefront aberration combinations that favour myopia progression; while 0 (black) indicates combinations that discourage myopia progression (i.e. do not provide stimulus for eye growth).

The majority of the black filled circles 1304 are in the region governed by negative SSA, with a few exceptions. Further, combinations in which PSA and TSA have the same sign coupled with negative SSA seem to provide a protective effect against myopia progression. The combinations of PSA, SSA, TSA and QSA that have a protective effect against myopia progression under the optical feedback explanation of emmetropisation (which include the black areas shown in Figure 13) can be summarised as shown in the Table 1.

SNo	Specific higher order aberration in addition to defocus	Magnitude and sign of the higher order aberration
1	PSA only	-0.30μm <= PSA < 0.125μm
2	SSA only	-0.30μm <= SSA <= 0.075μm
3	TSA only	-0.30μm <= TSA <= 0.075μm
4	QSA only	-0.10μm <= QSA <= 0.075μm
5	PSA & SSA	-0.30μm <= PSA <= 0.20μm and -0.25μm <= SSA <= 0.025μm
6	PSA & TSA	-0.30μm <= PSA < =0.30μm and TSA = (PSA/2)μm +/- 0.075μm
7	PSA & QSA	-0.30μm <= PSA < =0.30μm and QSA = (|PSA|/3) μm +/- 0.075μm
8	PSA, SSA, TSA	-0.30μm <= PSA < -0.05μm & 0.05μm < PSA < 0.30μm; -0.30 μm <= SSA < 0.05 μm; -0.20μm <= TSA <-0.025μm & 0.025μm< TSA < 0.20μm;
9	PSA, SSA, TSA and QSA	-0.30μm <= PSA < -0.05μm & 0.05μm < PSA < 0.30μm; -0.30 μm <= SSA < 0.05 μm; -0.20μm <= TSA <-0.025μm & 0.025μm< TSA < 0.20μm; -0.20μm <= QSA <-0.025μm & 0.025μm<QSA < 0.20μm;

Table 1 Combination sets of higher order aberrations which discourage the eye growth (i.e. potential treatment for myopia), according to certain embodiments.

The majority of the white circles 1302 are in the region governed by positive SSA, with a few exceptions. Further, combinations in which the PSA and TSA have the same sign coupled

with positive SSA may provide a treatment effect for hyperopia. The combinations of PSA, SSA, TSA and QSA that have a treatment effect against hyperopia under the optical feedback explanation of emmetropisation (including the white areas shown in Figure 13) can be summarised as shown in the Table 2.

SNo	Higher order aberration in addition to defocus	Magnitude and sign of the higher order aberration
1	PSA only	0.30 μm => PSA >= 0.125 μm
2	SSA only	0.30 μm => SSA > 0.075 μm
3	TSA only	0.30 μm => TSA > 0.075 μm
4	QSA only	-0.30 μm <= QSA <= -0.125 μm or 0.30 μm => QSA > 0.075 μm
5	PSA & SSA	-0.30 μm <= PSA <= 0.30 μm and 0.30 μm >= SSA > 0.075 μm
6	PSA & TSA	-0.30 μm <= PSA < =0.30 μm and (PSA/2) μm + 0.075 μm <= TSA < 0.30 μm or -0.30 μm <= TSA < (PSA/2) μm - 0.075 μm
7	PSA & QSA	-0.30μm <= PSA < =0.30μm and QSA in the range -0.20 to 0.20 μm but excluding values where QSA = (|PSA|/3) μm +/- 0.075μm
8	PSA, SSA, TSA	-0.30μm <= PSA < -0.05μm & 0.05μm < PSA < 0.30μm; 0.075 μm <= SSA < 0.30 μm; -0.20μm <= TSA <-0.025μm & 0.025μm< TSA < 0.20μm;
9	PSA, SSA, TSA and QSA	-0.30μm <= PSA < -0.05μm & 0.05μm < PSA < 0.30μm; 0.075 μm <= SSA < 0.30 μm;

		-0.20μm <= TSA <-0.025μm & 0.025μm< TSA < 0.20μm; -0.20μm <= QSA <-0.025μm & 0.025μm<QSA < 0.20μm;

Table 2 Combination sets of higher order aberrations which encourage eye growth (i.e. potential treatment for hyperopia), according to certain embodiments.

Accordingly, when designing a lens, optical device or method of altering the eye, the aberrations may be selected to provide a combination of the aforementioned aberrations that provide for either a protective effect against eye growth for example for myopia, or which encourage eye growth for example for hyperopia. The combination of aberrations may be applied in combination with the required correction of any myopic defocus or hyperopic defocus.

From the foregoing description, it is apparent that the spherical aberration terms, including the primary, secondary, tertiary and quaternary SA terms influence RIQ and through focus RIQ. In addition, it has been found that much higher orders of spherical aberration may also influence RIQ and through focus RIQ. In various embodiments different combinations of spherical aberration are used, including embodiments using combinations of two or more spherical aberration terms that provide a required or acceptable through focus RIQ profile, together with a required or acceptable RIQ at a particular focal length (e.g. distance vision). In certain embodiments, characterizations of one or more of the spherical aberrations may also be used.

Section 6: The instantaneous gradient of the image quality

The foregoing description of stimulus for eye growth can be explained under an optical feedback mechanism that is based on the location of a peak on-axis RIQ. In certain examples, another alternative approach considered to describe the stimulus for eye growth is via the slope of TFRIQ at the retina. In some embodiments, lenses, methods and/or devices utilise the gradient or slope of the RIQ to control myopia progression, with or without astigmatism. In other embodiments, lenses, methods and/or devices utilise the gradient or slope of the RIQ to treat hyperopia, with or without astigmatism. The gradient or slope of RIQ may be considered for one or more of the following variants of RIQ: a) monochromatic RIQ with or without considering effect of accommodation, b) polychromatic RIQ with or without considering effect of accommodation, c) global RIQ, d) RIQ considered with myopic impetus time signal, e) global

RIQ with myopic impetus time signal, each of which is described herein.

In certain embodiments, the lenses, devices and/or methods disclosed herein may be applied to provide stimulus under this optical feedback mechanism explanation of emmetropisation. Embodiments for addressing eye growth under the optical feedback explanation of emmetropisation (e.g. to address myopia progression or to seek to stimulate eye growth to correct hyperopia) may use aberrations to affect one, two or more of the location of the minima, or substantial minima, of the function S relative to the retina and the gradient of the function S through the retina.

In the following description it is assumed that a positive measure of the gradient of the TFRIQ (increasing RIQ posterior to the retina) provides a stimulus for the development and progression of myopia, while a negative measure of the same retards or halts myopia progression. Figure 14 is an exemplary that shows a plot of RIQ for two different cases, 1402 and 1404, as a function of through focus in the direction posterior to the retina, according to certain embodiments. The cases are two different combinations of PSA, SSA and TSA that produce identical, or substantially identical, retinal RIQ. As can be seen from the figure, although both sets of selected aberrations produce similar image quality at the retina (defocus=0), with the introduction of defocus (in the direction of eye growth) the retinal image quality of test case 1402 ramps up indicating stimulus for eye growth, while test case 1404 indicates that there would be no stimulus for growth, as the retinal image quality degrades further in the direction of eye growth.

From the results described herein that indicate the effects of HOA on image quality and the resulting progression of myopia, it is possible to determine the relevant HOA combinations that may be used in lenses, optical devices, and/or effected using optical surgery, which, where relevant in combination with the eye's aberrations, may result in the HOA combinations that inhibit or retard eye growth for the treatment of myopia progression. In order to slow down eye growth in myopia, compensating optical devices and/or surgical procedures may be used that, in combination with the optics of the eye, may result in a combination of HOA that results in a negative gradient of TFRIQ, as shown in example 1404 (Figure 14). For treating hyperopia in certain applications, compensating optical devices and/or surgical procedures may be used that, in combination with the optics of the eye, may result in a combination of HOA that results in a positive gradient of TFRIQ, as shown in example 1402 (Figure 14).

If an aberration profile has a varying RIQ across a through focus range, then the slope of through focus RIQ at a particular focal length may be changed by selecting a suitable defocus term C(2,0) with the considered RIQ profile. For example, if the slope is positive at a first level of through focus and negative at a second level of through focus, the slope at the retina of a recipient eye may be selected by selectively introducing defocus at either the first or second level. Examples of aberration profiles that have varying RIQ slopes at different levels of defocus are provided herein in relation to embodiments of aberration profiles for application to presbyopia. Many of the embodiments described for presbyopia may be applied to provide a stimulus to retard and/or encourage eye growth under the optical feedback explanation of emmetropisation described herein. Typically, younger people have progressing myopia and as such they may not be experiencing presbyopia. Accordingly, the aberration profile selected may place less weight on achieving high RIQ over a large through focus range and more weight on achieving the highest RIQ at the retina for distance vision in combination with providing a negative slope RIQ profile through the retina (i.e. decreasing RIQ in the direction of eye growth). For the young hypermetropes, again, the selected aberration profile may place less weight on achieving high RIQ over a large through focus range and more weight on achieving the highest RIQ at the retina for distance in combination with provision of a positive slope of RIQ profile behind the retina (in the direction of eye growth).

In certain embodiments, a lens, device and/or method may incorporate an aberration profile that provides, i) an acceptable on-axis RIQ; and ii) a through-focus RIQ with a slope that degrades in the direction of eye growth; to an eye with progressing myopia or an eye that is identified as at risk of developing myopia. In certain embodiments, the measure of acceptable on-axis RIQ can be considered from one or more of the following: on-axis RIQ of 0.3, on-axis RIQ of 0.35, on-axis RIQ of 0.4, on-axis RIQ of 0.45, on-axis RIQ of 0.5, on-axis RIQ of 0.55, on-axis RIQ of 0.6, on-axis RIQ of 0.65, or on-axis RIQ of 0.7. In certain embodiments, the candidate myopia eye may be considered with or without astigmatism.

In certain embodiments, a lens, device and/or method may incorporate an aberration profile that provides, i) an acceptable on-axis RIQ; and ii) a through-focus RIQ with a slope that improves in the direction of eye growth; to an eye with hyperopia. In certain embodiments, the measure of acceptable on-axis RIQ can be considered from one or more of the following: on-axis RIQ of 0.3, on-axis RIQ of 0.35, on-axis RIQ of 0.4, on-axis RIQ of 0.45, on-axis RIQ of 0.5, on-axis RIQ of 0.55, on-axis RIQ of 0.6, on-axis RIQ of 0.65, or on-axis RIQ of 0.7. In certain

embodiments, the candidate hyperopic eye may be considered with or without astigmatism. In certain embodiments, the gradient or slope of RIQ may be considered for one or more of the following variants of RIQ: a) monochromatic RIQ with or without considering effect of accommodation, b) polychromatic RIQ with or without considering effect of accommodation, c) global RIQ, d) RIQ considered with myopic impetus time signal, e) global RIQ with myopic impetus time signal, each of which is described herein.

Section 7: Aberration design or selection process

In some embodiments, determining the aberration profile required in a lens, optical device and/or resulting from a procedure includes first identifying the HOA present in the eye. In some embodiments, determining the characterization of the aberration profile required in a lens, optical device and/or resulting from a procedure includes first identifying the HOA present in the eye. Measurements may be taken, for example, using wavefront eye exams that use aberrometry such as with a Shack-Hartmann aberrometer. The eye's existing HOA may then be taken into account. In addition, one or more HOA effects inherent in the lenses or optical devices may also be taken into account.

When the requirement is for a lens that provides stimulus for eye growth or to retard eye growth, these existing HOA are then compared to HOA combinations that inhibit or retard myopia progression (for example as discussed above with reference to Figures 5 to 14) to determine one or more additional HOA that may be required to reduce or retard or encourage eye growth under the optical feedback mechanism of emmetropisation. These additional combinations are then implemented in the design of lenses or optical devices or implemented using optical surgery. Flowcharts in Figures 15 and 16 provide a summary of suitable methods, according to certain embodiments.

Alternatively, in certain applications, the eye's existing aberrations may be disregarded and an aberration profile that provides the required through focus RIQ slope may be provided for the eye by a lens, In certain applications a removable lens so that different aberration profiles may be trialled if required. The aberration profile resulting from the combination of the aberration profile of the lens and the eye may then be measured to determine if the RIQ characteristics are acceptable (for example, provide a particular through focus RIQ slope and acceptable RIQ for distance vision). Alternatively, different lenses may be placed on the eye

with measures of objective and/or subjective vision determining which lens to select. Where the lens is selected to provide stimulus inhibiting or encouraging eye growth without regard to the eye's existing aberrations, the selected aberration profile may be one with generally higher values of spherical aberration, so that the sign of the slope is not changed by lower level of HOA in the eye. In certain applications, the goal of the optimisation routine of the merit function in search of combination of HOA may be different. For example, when considering presbyopia the goal may be a combination of aberrations that provide high RIQ over a large through focus range. Where peripheral vision is useful, then the objective may include high RIQ over a large range of field angles. Accordingly, in various embodiments the HOAs are utilised to optimise for the goals of a combination of high RIQ at the retina and one or more of a low slope through focus RIQ, a low change in RIQ with pupil diameter and a high RIQ in the peripheral field.

In certain applications, an acceptable high RIQ is considered to be an RIQ above 0.7, above 0.65, above 0.6, above 0.55, above 0.5, above 0.45, above 0.4, above 0.35, or above 0.3. In certain applications, an acceptable low change in RIQ with pupil diameter may be considered the change in one or more of the following ranges: RIQ change between 0 and 0.05, between 0.05 and 0.1, or between 0.1 and 0.15. In certain other applications, an acceptable low slope of through focus RIQ may be considered from one or more of the following: slope of less than zero, slope of equal to zero, slope of greater than zero, slope of about zero, slope ranging from -0.5 to zero, slope ranging from 0 to 0.5, slope ranging -1 to zero, slope ranging 0 to 1, slope ranging -1 to -0.5, or slope ranging 0.5 to 1. The high RIQ, low change in RIQ and low slope of TF RIQ provided may be combined in or more combinations. For example, the combination of a high RIQ of 0.40 or above, a low change in RIQ with pupil diameter between 0 and 0.05 and low slope of TFRIQ of about zero may be applied to certain embodiments.

In other applications, the combination of a high RIQ of 0.3 or above, a low change in RIQ with pupil diameter between 0 and 0.075 and the low slope of TFRIQ ranging from -0.25 to 0.25 or -0.5 to 0.5 may be applied.

The examples that follow have been selected using the RIQ measure in Equation 2. The initial set of designs for analysis was found by computing this RIQ for all, or for a substantially number of, combinations of SA Zernike coefficients up to the 10th order. The coefficients used were constrained to the range -0.3μm to 0.3μm and constrained to be a value that is a multiple of 0.025μm. In certain embodiments, the RIQ used may be based on an approximation or characterization of Equation 2.

An analysis of the initial set of designs included: 1) identifying optimised combinations of Zernike coefficients that provide a high RIQ and a negative slope through focus RIQ about the retina; 2) consideration of the RIQ and through focus RIQ and change in RIQ and through focus RIQ at different pupil sizes; and 3) consideration of the RIQ across the horizontal visual field. The relative weight given to these stages of evaluation may vary for the particular recipient. For the purposes of identifying the following examples, most weight was given to the first criteria.

Section 8: Examples of optical designs addressing the slope of through focus RIQ

Examples of designs for affecting stimulus for eye growth under an optical feedback mechanism are provided herein. The examples below are rotationally symmetric. However, astigmatic designs and other non-rotationally symmetric designs may be produced. When a deliberate decentration of the symmetric designs is imposed so that the optical axes of the correcting contact lens coincides with a reference axis of the eye say pupillary axis or visual axis, some residual amounts of asymmetric aberrations like coma and trefoil can be induced, these may be compensated by the choice of additional higher order asymmetric terms. Figures 17 to 25 are exemplary that show the power profile graphs of sample designs that provide a RIQ that degrades in the direction of eye growth for on-axis vision (i.e. at zero field angle), thus providing a stimulus to inhibit eye growth under the optical feedback mechanism explanation of the emmetropisation process, according to certain embodiments. The aberration profile graphs are described as the axial power variation in Dioptres across the optic zone diameter. The examples provided may have application to a progressing myope whose spherical refractive error is -2D and this information is indicated by a dual gray line on the power profiles.

Figure 26 is an exemplary that shows the details of a sample design that may be used for hyperopia treatment, according to certain embodiments. This designs was produced by taking a specific aberration profile as an input parameter that would produce a positive gradient of TF retinal image quality in the direction of eye growth, as indicated in Table 2 and optimising the power profile (front surface of correcting contact lens) to achieve a required positive gradient. The lens design is described as the axial power variation in Dioptres across the optic zone diameter. The example provided may have application to a non-progressing hyperope whose spherical refractive error is +2D and this information is indicated by a dual gray line on the power profile.

As explained herein, the example power profiles shown in Figures 17 to 26 were selected based on the slope of RIQ around the retina, according to certain embodiments. Across these examples, substantial variations in the value of RIQ may occur. These variations occur on-axis, across the pupil diameter, and at different field angles. Additional selection criteria are the value of RIQ and the change in RIQ with field angle. In particular, the selection may be made to maximise one or more of RIQ on-axis, across the pupil diameter (with or without reduction in light of the Stiles-Crawford effect) and at different field angles. In addition, the size of the pupil of the recipient may also be used as a selection criterion – e.g., a first aberration profile may better suit a first recipient with a normal pupil size of 4 mm and a second aberration profile may better suit a second recipient with a normal pupil size of 5 mm. The 'normal' pupil size may optionally be selected having regard to lifestyle factors, such as the amount of time a person spends indoors versus outdoors. Additional examples referred to below incorporate these selection criteria. First however, to provide a point of comparison, the RIQ performance of a single vision lens is described and shown in Figure 27.

Figure 27 is an exemplary that shows a graph of a measure of a through focus RIQ metric, according to certain embodiments, which in this case, and in the following examples, is Visual Strehl Ratio (monochromatic). The RIQ may result, for example, from a single vision contact lens with a power of -2D used to correct a recipient model myopic eye with -2D only. The horizontal (independent) axis shows the through focus, in Dioptres. The zero (0) value on the horizontal axis represents the location of the focal point of the single vision lens and the vertical (dependent) axis shows the RIQ. Three plots are provided, one for on-axis (circles), one for a field angle of 10 degrees (triangles) and one for a field angle of 20 degrees (crosses).

As used in this example described herein, the term global is used to refer to consideration across a range of field angles, including zero. Thus, the graph shows Global through focus RIQ, as it includes plots across a range of field angles. While a single vision lens has symmetrical RIQ on-axis at zero field angle, it has asymmetrical through focus RIQ at non-zero field angles, including both at 10 and 20 degrees. In particular, the graph shows that RIQ improves in the direction of eye growth at non-zero field angles, according to certain embodiments. Under the optical feedback mechanism explanation of emmetropisation, peripheral as well as on-axis vision provides a stimulus for eye growth.

Figure 28 is an exemplary that shows a graph of RIQ for an embodiment of a lens (named 'Iteration A1') selected to address the optical feedback mechanism explanation of

emmetropisation where eye growth is to be discouraged (e.g. to address progressing myopia or to address a risk of developing myopia), according to certain embodiments. The data for Figure 28 was prepared for a pupil size of 4 mm and to address the same, or substantially the same, level of myopia as for the Single Vision Iteration. Comparing Figure 28 with Figure 27, the RIQ no longer improves in a direction of eye growth for non-zero field angles. In particular, the RIQ has a strong trend towards degrading in the direction of eye growth for 10 degrees off-axis. While there may be a slight improvement or no substantially no change in RIQ about the retina at 20 degrees off-axis, the overall effect is strongly biased towards degrading RIQ in the direction of eye growth. Figure 29 shows a power profile that result in the RIQ graph of Figure 28.

Figure 30 is an exemplary that shows a graph of RIQ for certain embodiments of a lens (Iteration A2) selected to address the optical feedback mechanism explanation of emmetropisation. The data for Figure 30 was prepared for a pupil size of 5 mm.

Figures 31 and 32 are exemplary that show graphs of the RIQ for two other embodiments of a lens (Iteration C1 and Iteration C2 respectively) selected to address the optical feedback mechanism explanation of emmetropisation, but in this case to provide improving RIQ in the direction of eye growth (e.g. to provide a stimulus to an eye to grow to correct hyperopia). Figures 31 and 32 show exemplary embodiments selected with different weights to the selection criteria. In the power profile that gives Figure 31, achieving a high on-axis RIQ was given more weight than achieving a high RIQ across a large range of field angles.

In the power profile that gives Figure 32, more weight was given to providing a high RIQ across a large range of field angles than to achieving a high RIQ on-axis. In certain applications, an acceptable high RIQ across a large field angles is considered to be an RIQ above 0.6, above 0.55, above 0.5, above 0.45, above 0.4, above 0.35, or above 0.3. Table 3 lists the defocus and higher order aberrations coefficients up to 20th order, in microns, over a 5 mm pupil diameter for the above described power profiles.

Iteration	C(2,0)	C(4,0)	C(6,0)	C(8,0)	C(10,0)	C(12,0)	C(14,0)	C(16,0)	C(18,0)	C(20,0)
Single Vision Lens	-1.800	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Iteration A1	-1.568	0.107	-0.017	-0.016	-0.022	-0.008	0.026	0.005	-0.016	0.003

Iteration A2	-1.562	0.115	-0.011	-0.011	-0.019	-0.007	0.025	0.004	-0.017	0.005
Iteration C1	1.468	-0.135	0.020	0.029	0.036	0.011	-0.036	-0.008	0.022	-0.003
Iteration C2	1.468	-0.116	0.035	0.010	-0.013	-0.030	-0.014	0.025	0.004	-0.016

Table 3 Defocus and higher order Spherical aberration coefficients over a 5 mm pupil for a single vision lens and four exemplary embodiments that provide a required slope for through focus RIQ.

Section 9: Application to presbyopia

Presbyopia is a condition where with age an eye exhibits a progressively diminished ability to focus on near objects. The ability to focus on near objects may be referred to as accommodative ability. Pre-presbyopia is an early stage at which patients begin to describe symptoms of diminished ability to focus on near objects. The ability to focus on near objects without use of lenses and/or devices disclosed herein is considered as a non-presbyopic condition. Certain embodiments are directed to providing lenses, devices and/or methods that are configured such that the embodiments provide visual performance that is substantially comparable to the visual performance of a pre-presbyope or non-presbyope over a range of distances with minimal ghosting.

For example, where the near distance is the range of 33 cm to 50 cm or 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm, 50 cm to 80 cm or 50 cm to 70 cm; and far distance is the range of 100 cm or greater, 80 cm or greater or 70 cm or greater. Other distances or range of distances may also be used.

In certain applications, extending the through focus RIQ may provide one or more benefits in the context of presbyopia. The reduced ability of the eye to see at near due to the reduced accommodation may be partially compensated and/or mitigated by using the extended through focus of certain approaches described herein. The benefits may include visual performance at near close to or approaching the visual performance of a properly prescribed single-vision lens for near.

Other benefits may include (i) visual performance at far and intermediate distances substantially equivalent to the visual performance of a properly prescribed single-vision lens for

far visual distance; (ii) visual performance over intermediate and far distances that is at least substantially equivalent to the visual performance of a correctly prescribed single-vision lens at the far visual distance; (iii) visual performance, along a range of substantially continuous visual distances, including intermediate and far distances, wherein the visual performance of the multifocal lens is at least substantially equivalent to the visual performance of a correctly prescribed single-vision lens at the far visual distance; and/or (iv) providing visual performance at far and intermediate distances substantially equivalent to the visual performance of a properly prescribed single-vision lens at the far visual distance with minimal, or substantially minimum, ghosting.

In certain embodiments, the visual distance over one or more of the following ranges i.e. near intermediate and far distances may be continuous, substantially continuous or continuous over a portion of the near distance or distances, the intermediate distance or distances, or far distance or distances. This may also be true for optical infinity. In certain embodiments, continuous may be defined as near distance range from 33 cm to 50 cm, 40 cm to 50 cm or 33 to 60 cm; intermediate distance range from 50 cm to 100 cm, 50 cm to 80 cm or 50 cm to 70 cm; and far distance range from 100 cm or greater, 80 cm or greater or 70 cm or greater. According to certain disclosed lenses, the lens is configured to provide the visual performance, along continuous visual distances, including near distances, intermediate distances, and far distances.

In some embodiments the through focus RIQ is extended further by taking a monocular optimisation approach, or using one or more of the monocular methods disclosed herein. The monocular optimisation approach in certain embodiments is achieved by extending the through focus RIQ to optimise one eye for distance vision and the other eye for near. In certain embodiments, this optimisation is by selecting different base powers (i.e. effective refractive prescriptions) for the lenses. The extended through focus (for example RIQ) for each lens allows the base powers to be separated, or used without sacrificing, or substantially reducing, far, intermediate, or near vision between the two base powers.

In certain embodiments, one or more of the monocular methods disclosed herein may be used to extend the binocular through-focus RIQ, or the through-focus RIQ, by using an aberration profile for one eye and a different aberration profile for the other eye. The extended through-focus RIQ of each lens optimises one eye for distance vision and the other eye for near without substantially reducing, far, intermediate, and/or near vision, and minimal, or substantially minimal, ghosting with the two aberration profiles.

In certain embodiments, one or more of the monocular methods disclosed herein may be used to extend the binocular through-focus RIQ, or the through-focus RIQ, by using an aberration profile and a base power for one eye and a different aberration profile and a different base power for the other eye. The extended through-focus RIQ of each lens optimises one eye for distance vision and the other eye for near without substantially reducing, far, intermediate, and/or near vision, and minimal, or substantially minimal, ghosting with the two aberration and base power profiles.

Under the monocular approach, in some embodiments, selection of an aberration profile may give a higher priority to the consideration of the RIQ and through focus RIQ, and change in RIQ and through focus RIQ at different pupil sizes (which reflect the change in the eye with different accommodation levels and illumination levels).

Similarly, a lens or optical device may be designed as a bifocal or multifocal or omnifocal lens, with one or both of the parts incorporating aberration profiles as described herein to extend TFRIQ. A combination of bifocal, multifocal, omnifocal lenses, devices, methods and procedures can be used either in one eye or synergistically in both eyes by appropriate selection for each eye that will enhance the binocular performance. For example, one eye may be biased for optimal vision for far and the other eye for optimal vision at near.

A combination of bifocal, multifocal, omnifocal lenses, devices and/or the monocular method that may increase visual performance over a range of dioptric distances by about 1, 1.25, 1.5, 1.75, 2, or 2.25D. For example, with reference to such method of prescribing bifocal lenses: one eye may have far distance vision in the upper quadrants of performance (RIQ about 0.35, 0.4, 0.45, 0.5 or another selected) and near vision in the lower quadrants of performance (RIQ about 0.1, 0.12, 0.15, 0.17, 0.2 or another selected) and the other eye may have intermediate vision in the upper quadrants of performance (RIQ about 0.35, 0.4, 0.45, 0.5 or another selected) and near vision in the lower quadrants of performance (RIQ about 0.1, 0.12, 0.15, 0.17, 0.2 or another selected).

When different base powers, power profiles or aberration profiles are used in two different eyes; the different base powers, power profiles, aberration profiles may be selected so that the through focus RIQ overlaps to increase the binocular through-focus RIQ. For example, in certain embodiments, the base powers may be selected so that in combination the Visual Strehl Ratio does not drop below 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.40 or another selected value, between the combined RIQ profiles.

A) Examples for presbyopia

Figure 36 shows a graph of through focus RIQ (in this case Visual Strehl Ratio) for seven power profiles, according to certain embodiments. In this figure the vertical axis (RIQ) is defined on a logarithmic scale. Figure 36 was obtained for a 5 mm pupil size and an eye with no myopia or hyperopia and no other higher order aberrations. One or more power profiles may be adapted to a myopic or hyperopic eye by incorporating an appropriate correcting defocus term, which does not affect the higher order aberrations defining the power profiles used for form Figure 36.

The seven power profiles are: a power profile that may appear in a conventional centre-distance aspheric multifocal lens (indicated by triangles in Figure 36); a power profile that may appear in a conventional centre-near multifocal lens (indicated by 'x' in Figure 36); a power profile that may appear in a centre-distance concentric bifocal lens (indicated by filled '□' in Figure 36); a power profile that may appear in a centre-near concentric bifocal lens (indicated by empty '◊' in Figure 36) and three iterations (Iteration B1, Iteration B2, Iteration B3) including a favourable combination of spherical aberration (indicated by filled circles, bold '+' signs and a concentric circle pairs, respectively, in Figure 36).

The power profiles for each of these are shown in Figures 37 to 43. The centre-distance and centre-near aspheric multifocals had the centre component extend to about 2 mm and the outer zone power commence at a radius of about 1.8 mm. A linear transition was provided between the near and distance power zones. The concentric bifocals both had a ring structure, alternating between an additional power of 2 Dioptres and no addition power (also referred to as base distance power).

Table 4 lists the defocus and higher order spherical aberration coefficients up to 20th order, in microns, over a 5 mm pupil diameter, for the three exemplary embodiment power profiles, namely: Iteration B1 (Figure 41), Iteration B2 (Figure 42) and Iteration B3 (Figure 43), respectively.

Iteration	Iteration B1	Iteration B2	Iteration B3
C(2,0)	-0.096	-0.092	0.033
C(4,0)	-0.135	0.032	0.003
C(6,0)	0.02	0.074	0.077
C(8,0)	0.029	-0.015	-0.045

C(10,0)	0.036	-0.006	-0.023
C(12,0)	0.012	-0.018	0.01
C(14,0)	-0.036	-0.009	0.014
C(16,0)	-0.01	0.007	0.007
C(18,0)	0.022	0.011	0.003
C(20,0)	0	0.002	-0.014

Table 4 Defocus and Spherical aberration coefficients of three exemplary embodiments for presbyopia.

Table 5 lists out the defocus and higher order spherical aberration coefficients up to 20th order, in microns, over a 5 mm pupil diameter, for the described power profiles, namely, centre-distance aspheric multifocal (Figure 37), and centre-near aspheric multifocal (Figure 38, respectively.

Iteration	Centre-Distance aspheric multifocal	Centre-Near aspheric multifocal
C(2,0)	1.15	0.324
C(4,0)	0.181	-0.244
C(6,0)	-0.09	0.114
C(8,0)	0.02	-0.021
C(10,0)	0	-0.013
C(12,0)	0	0.011
C(14,0)	0	0
C(16,0)	0	0
C(18,0)	0	0
C(20,0)	0	0

Table 5 Defocus and Higher order spherical aberration coefficients of both centre-distance and centre–near type aspheric multifocal lenses.

In the aspheric multifocal lenses the spherical aberration coefficients progressively decrease in absolute magnitude with an increase in order. This is in contrast to the power profiles of Iteration B1, Iteration B2 and Iteration B3, which include at least one higher order spherical aberration term with an absolute value coefficient greater than the absolute value of the

coefficient for a lower order term. This characteristic is present in one or more of the embodiments of power profile described herein. From Figure 36, it can be noted that the centre-distance aspheric multifocal has a RIQ of 0.23 at 0D, which substantially inferior than the other power profiles, according to certain embodiments. However, performance of this lens as gauged by the RIQ metric is maintained relatively constant over a large through focus range. For example, at -0.4Dioptres the RIQ is about 0.2, at 0.67 the RIQ is about 0.18 and at -1Dioptres, the RIQ is about 0.12.

The centre-near aspheric multifocal has a RIQ at 0D is about 0.5. With this exemplary design, the RIQ falls to about 0.24 at -0.67Dioptres (still better than the centre-distance aspheric multifocal). However, beyond that the centre-near aspheric multifocal has a rapidly decreasing RIQ, as can be seen at -1Dioptre the value of RIQ is about 0.08. Both of the concentric bifocals (centre-distance and –near) have a low RIQ of 0.13 and 0.21 at 0D. Both of the concentric bifocals maintain their level of RIQ or better over a range of approximately 1.1 Dioptres.

Iteration B1, Iteration B2 and Iteration B3 have at least as good RIQ at 0D, as the centre near bifocal and also better RIQ across the TF range between -0.65D and 0.75D as the eye accommodates. For example Iteration B2 has an RIQ of about 0.53 at -0.4 Dioptres, about 0.32 at -0.67 Dioptres and about 0.13 at -1Dioptres. Through focus performance (RIQ) of Iteration B1, Iteration B2 and Iteration B3 can be further extended. This extension is achieved by shifting the curves to the left in Figure 36. However, the performance of the centre-near aspheric multifocal lens, in this exemplary, cannot be shifted in this manner without substantially affecting performance, due to the asymmetric RIQ that decreases substantially more rapidly for plus powers (right hand side of Figure 36).

For example, the three exemplary iterations have an RIQ of about 0.40 at +0.55D. Combining the spherical aberration terms with a +0.55D defocus term will shift the RIQ value for distance vision to the value for +0.55D in Figure 36. Considering Iteration B2 again, the through focus performance (RIQ) would be modified as follows: an RIQ of about 0.4 at distance vision, an RIQ of about 0.53 at -0.4Dioptres, about 0.64 at -0.67Dioptres, about 0.52 at -1Dioptres, about 0.40 at -1.1Dioptres, and about 0.15 at -1.5 Dioptres.

By shifting the distance vision point in a lens with combinations of HOA that extend through focus RIQ performance, then the lenses, devices and/or methods that provide the combination of HOA can have a substantially improved through focus performance. This is achieved while maintaining at least as good RIQ as a centre near aspheric multifocal and

substantially improved RIQ in comparison to a centre distance aspheric multifocal. The amount of defocus plus power added to shift the RIQ curves is a matter of choice, representing a trade-off between distance vision RIQ and near vision RIQ. Table 6 shows the defocus (leftmost column) and RIQ values for the power profiles described above. It also shows the defocus values shifted by +0.55D, applicable when to Iteration B1, Iteration B2 and/or Iteration B3 is modified by this amount.

Defocus (D)	Centre-	Centre-	Iteration	Iteration	Iteration	Centre-	Centre-	Defocus
-1.1085	0.1021	0.0601	0.1342	0.0918	0.0971	0.2025	0.1349	-0.6085
-0.9977	0.1212	0.0768	0.1831	0.1338	0.1228	0.2447	0.1524	-0.4977
-0.8868	0.1407	0.1062	0.2394	0.1882	0.1577	0.2913	0.1675	-0.3868
-0.7760	0.1598	0.1574	0.2957	0.2511	0.2095	0.3362	0.1789	-0.2760
-0.6651	0.1776	0.2383	0.3423	0.3160	0.2830	0.3700	0.1851	-0.1651
-0.5543	0.1931	0.3481	0.3867	0.4262	0.3723	0.3839	0.1855	-0.0543
-0.4434	0.2060	0.4699	0.4550	0.5318	0.4583	0.3735	0.1805	0.0566
-0.3326	0.2162	0.5715	0.4992	0.6099	0.5266	0.3417	0.1709	0.1674
-0.2217	0.2237	0.6185	0.5110	0.6451	0.5691	0.2969	0.1584	0.2783
-0.1109	0.2284	0.5913	0.4924	0.6369	0.5879	0.2495	0.1444	0.3891
0.0000	0.2304	0.4980	0.5014	0.5993	0.5906	0.2076	0.1300	0.5000
0.1109	0.2294	0.3702	0.4924	0.5511	0.5825	0.1754	0.1167	0.6109
0.2217	0.2249	0.2468	0.5110	0.5055	0.5609	0.1539	0.1055	0.7217
0.3326	0.2160	0.1549	0.4992	0.4648	0.5182	0.1418	0.0973	0.8326
0.4434	0.2048	0.1010	0.4550	0.4232	0.4513	0.1367	0.0924	0.9434
0.5543	0.2000	0.0758	0.3867	0.3741	0.3672	0.1358	0.0908	1.0543
0.6651	0.2173	0.0650	0.3082	0.3154	0.2815	0.1363	0.0917	1.1651
0.7760	0.2727	0.0588	0.2327	0.2511	0.2095	0.1362	0.0940	1.2760
0.8868	0.3701	0.0535	0.1694	0.1882	0.1577	0.1347	0.0962	1.3868
0.9977	0.4907	0.0491	0.1219	0.1338	0.1228	0.1325	0.0992	1.4977

1.1085	0.5962	0.0458	0.0896	0.0918	0.0971	0.1305	0.1087	1.6085

Table 6 RIQ values for two bifocal lenses, two concentric bifocal lenses and three aberration profiles for extended through focus RIQ.

B) Effect of pupil size

Figures 44 to 46 show the variation in through focus RIQ with pupil size for Iteration B1, Iteration B2 and Iteration B3 respectively, according to certain embodiments. The exemplary RIQ profiles are relatively stable, in that the RIQ retains the combination of a relatively high RIQ (in comparison to, for example, a centre distance aspheric multifocal) in combination with a relatively long through focus range (in comparison to, for example, a centre near aspheric multifocal). Figure sets 47, 48 and 49, 50 show the variation in through focus RIQ with pupil size for the two concentric bifocals and two aspheric multifocals, respectively. From these figures it can be seen that, comparatively, the change in RIQ and through focus RIQ performance is less stable for these lenses than Iteration B1 (Figure 39), Iteration B2 (Figure 40) and Iteration B3 (Figure 41). Figures 39 to 50 are examples, according to certain embodiments.

C) Monocular design

As described herein, Iteration B2 (Figure 40) may provide an RIQ of 0.4 or above from distance vision to about an intermediate vergence of about 1.1 Dioptres. When appropriate level of defocus is added to the same iteration while correcting the other eye, TFRIQ can be extended from 1.1 Dioptres to up close, say 2.2D target vergence, i.e. binocularly combined the candidate eye may maintain an RIQ of 0.4 or above from distance test distance to all the way up to, or substantially up to 2.2 Dioptres. Using this monocular design approach and assuming the recipient accepts the monocular design, the combined through focus performance is substantially extended, according to certain embodiments, according to certain embodiments..

Referring to the through focus profiles shown in Figures 51 and 52, which are described herein, under the monocular design approach, one lens will be selected to have a base power (distance refractive prescription) that shifts the through focus curve to the extreme, or subs left (starting at -2.5D mark) and the other lens selected to have a base power that shifts the through focus curve slightly to the left (starting at -1.5D mark), according to certain embodiments.

Figures 51 and 52 show the TF RIQ of the design of two pairs of power profiles (Binocular 'Q' correction), according to certain embodiments. Each lens in the pair has been designed to extend RIQ in combination with the other lens in the pair. The defocus and higher order spherical aberration coefficients for these combinations are specified in Tables 7 and 8 respectively.

Combination	Right Eye	Left Eye
C(2,0)	0.28	0.57
C(4,0)	-0.1	0.125
C(6,0)	0.025	-0.075
C(8,0)	0.075	-0.075
C(10,0)	0.025	-0.025
C(12,0)	0.025	0
C(14,0)	0.025	0.025
C(16,0)	0.025	0.025
C(18,0)	0.025	-0.025
C(20,0)	0	-0.025

Table 7 Defocus and higher order spherical aberration coefficients of first exemplary embodiment for monocular design of lenses for presbyopia (Effective add of 1.5D in the negative direction of through-focus curve.

Combination	Right Eye	Left Eye
C (2,0)	0.433	0.866
C(4,0)	-0.1	-0.1
C(6,0)	-0.05	-0.05
C(8,0)	0.025	0.025
C(10,0)	0.025	0.025
C(12,0)	-0.025	-0.025
C(14,0)	-0.025	-0.025
C(16,0)	0	0
C(18,0)	0	0
C(20,0)	0	0

Table 8 Defocus and higher order spherical aberration coefficients of second exemplary embodiment for monocular design of lenses for presbyopia (Effective add of 2.5D in the

negative direction of through-focus curve.

The power profiles described in relation to Table 7 and Table 8 are examples of combinations of higher order aberrations that provide enhanced through-focus performance on the negative side of the through-focus function. Similarly, using this monocular design approach, the combined through-focus performance can also be substantially extended on the right side of the through-focus function, provided an appropriate level of defocus is added to a selected combination of higher order aberrations. Figures 53 and 54 show examples with a relatively constant RIQ (>0.35) over a range of defocus, in the positive direction of the through-focus function, according to certain embodiments. The defocus and higher order spherical aberration coefficients for these combinations are specified in Tables 9 and 10, respectively.

Combination	Right Eye	Left Eye
C (2,0)	-0.28	-0.43
C(4,0)	-0.125	-0.125
C(6,0)	-0.05	-0.05
C(8,0)	0.075	0.075
C(10,0)	0.025	0.025
C(12,0)	-0.025	-0.025
C(14,0)	0	0
C(16,0)	0	0
C(18,0)	0	0
C(20,0)	0	0

Table 9 Defocus and higher order spherical aberration coefficients of third exemplary embodiment for monocular design of lenses for presbyopia (Effective add of 1.5D in the positive direction of through-focus curve).

Combination	Right Eye	Left Eye
C (2,0)	-0.43	-0.86
C(4,0)	-0.125	-0.125
C(6,0)	-0.05	-0.05
C(8,0)	0.075	0.075
C(10,0)	0.025	0.025
C(12,0)	-0.025	-0.025

C(14,0)	0	0
C(16,0)	0	0
C(18,0)	0	0
C(20,0)	0	0

Table 10 Defocus and higher order spherical aberration coefficients of fourth exemplary embodiment for monocular design of lenses for presbyopia (Effective add of 2.5D in the positive direction of through-focus curve).

Section 10: Design for peripheral field

In some embodiments, when selecting a combination of HOA to form a power profile, the weight given to peripheral vision may be increased. This may, for example, be applicable when the recipient plays certain sports in which peripheral vision is important.

Figure 55 shows a graph of RIQ (again Visual Strehl Ratio), for three different power profiles that substantially equalise RIQ across the horizontal visual field, according to certain embodiments. The RIQ measures were obtained for a 5 mm pupil. The defocus and higher order spherical aberration coefficients for each power profile are shown in Table 11.

Iteration	Iteration A3	Iteration A4	Iteration A5
C(2,0)	-1.506	-1.504	-1.501
C(4,0)	0.111	0.114	0.117
C(6,0)	-0.04	-0.037	-0.034
C(8,0)	-0.015	-0.013	-0.01
C(10,0)	0.007	0.009	0.012
C(12,0)	0.025	0.027	0.029
C(14,0)	0.011	0.013	0.014
C(16,0)	-0.025	-0.024	-0.023
C(18,0)	-0.003	-0.002	-0.002
C(20,0)	0.017	0.016	0.015

Table 11 Defocus and higher order spherical aberration coefficients of three exemplary embodiments for substantially constant RIQ over extended horizontal field angles

The Iterations A3 (Figure 56), A4 (Figure 57) and A5 (Figure 58) produced an on-axis RIQ of about 0.5 across zero to 30 degrees field angle (if horizontal symmetry is assumed, that is

60 degrees in total across both nasal and temporal fields), according to certain embodiments. The RIQ on-axis is also about 0.5, which is lower than some other embodiments where degradation in RIQ below 0.5 with increasing field angle is permitted.

Accordingly, in certain embodiments, the RIQ on-axis may be traded-off against RIQ at high field angles. For example, RIQ may be permitted to drop to 0.2 at 30 degrees field angle (but remain at 0.5 or above for 20 degrees field angle and less), to allow a selection of HOA that increases on-axis RIQ above those shown in Figure 55. Power profile designs for peripheral vision may be selected for a lens designed to provide a slope of RIQ (providing stimulus to retard or encourage eye growth under the optical feedback mechanism explanation for emmetropisation), or correction/lenses for presbyopia (emmetropia, myopia or hyperopia) or for other eyes. In certain embodiments, high field angles are one or more of the following: 10 degrees, 20 degrees, 30 degrees or 40 degrees of the visual field. Other suitable high field-angles may also be used in certain applications.

Section 11: Selection of positive and negative phase

For a particular recipient of a lens, device and/or a method disclosed herein, a selection may be made between two power profiles of opposite phases. In this context, the term 'opposite phase' identifies power profiles that have identical, or substantially identical, magnitudes of specific combination sets of higher order aberrations over a desired pupil, while their signs are opposite to each other. Figures 59 and 60 show power profile iterations E1 and E2, which are examples of power profiles with opposite phases, according to certain embodiments. Table 12 reflects the magnitudes and signs of the higher order spherical aberration terms for iterations E1 and E2.

The lenses of opposite phase described herein may result in the same, or substantially the same, on-axis peak RIQ. The through focus RIQ performance of such phase profile pairs may be mirror images, or substantially mirror images, of each other across the Y-axis (i.e. shifted apart by defocus), as shown in Figure 61. However, this would result if the inherent higher order aberration profile is negligibly small (say for example primary spherical aberration in the range of -0.02μm to 0.02μm over a 5 mm pupil).

Iteration	Iteration E1	Iteration E2
C(2,0)	-2.015	-1.573
C(4,0)	-0.102	0.102
C(6,0)	0.021	-0.021
C(8,0)	0.019	-0.019
C(10,0)	0.025	-0.025
C(12,0)	0.01	-0.01
C(14,0)	-0.025	0.025
C(16,0)	-0.006	0.006
C(18,0)	0.016	-0.016
C(20,0)	-0.003	0.003

Table 12 Defocus and higher order spherical aberration coefficients of two exemplary embodiments with opposite phases (i.e. mirror imaged power profiles across the X-axis).

The interactions between the inherent aberration profiles of the candidate eyes and a selected phase profile may either have a) an improved or b) degraded effect on the objective and/or subjective optical and/or visual performance. As the TF RIQ is dependent on the inherent aberration profile, a phase profiles selected for instance may be useful to change the slope of TF RIQ in the direction that would favour the emmetropisation process for myopic or hyperopic eyes; or alternatively the same, or similar, phase profile may be used to mitigate the presbyopic symptoms in alternative candidate eyes.

Figures 62 and 63 show how the TFRIQ of opposite phase profiles are dependent on the inherent ocular aberration of the candidate eye (in this example positive spherical aberration), according to certain embodiments. Certain embodiments disclosed herein involve providing lenses of the same, or substantially same, design, but opposite phase and allowing the recipient to select the preferred phase. The process of selection can be via an objective assessment of TF RIQ performance metric and/or could be purely a subjective preference via visually guided tests.

Section 12: Combination identification and selection

As described herein for certain embodiments, it is possible to provide a desirable on-axis RIQ for distance and appropriate through focus RIQ that would enable better visual performance

for distance, intermediate and near vergences by choosing an appropriate combination of HOA. This combination of higher order aberrations may contain a correction for the inherent aberration profile of the test candidate. The Appendix A to this specification lists 78 combinations of higher order spherical aberration coefficients that provide both a usefully high RIQ and an option to provide an extended through focus RIQ in the negative direction (left hand side). Also shown in the Appendix A, as a point of comparison, is a combination which does not have spherical aberration, of any order. The Appendix B shows the TFRIQ values for the combinations listed in the Appendix A. The calculations were performed for a pupil size of 4 mm, however the approach, or method, may be extended to other appropriate and/or desired pupil sizes if required or desired. For example, the method may be used with a pupil size within one or more of following ranges: 1.5 to 8 mm, 2 to 8 mm, 2.5 to 8 mm, 3 to 7 mm, 3 to 8 mm and 3.5 to 7 mm. For example, the method may be used with pupil sizes of about 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5 or 8 mm.

The TFRIQ measures of the 78 aberration combinations are shown in Figure 64, the black line showing the symmetrical RIQ that has resulted from a combination that has no higher order aberrations, the lighter lines (i.e. gray lines) showing the enhanced performance in the negative direction of the TFRIQ function for the 78 combinations that involve higher order spherical aberration terms.

From Figure 64, a number of observations can be made. The 78 profiles with higher order spherical aberration terms provide an extended through focus performance in the negative direction, particularly when an appropriate selection of a negative power is made to shift the plotted through-focus profile towards negative defocus (left). The 78 profiles include a range over which RIQ is 0.1 or higher of at least 2 Dioptres. Several of the 78 profiles include a range over which RIQ is 0.1 or higher of at least 2.25 Dioptres. The 78 profiles include an RIQ (Visual Strehl Ratio – monochromatic) that peaks above 0.35. Many of the profiles include an RIQ that peaks above the thresholds of 0.4, 0.5, 0.6 and 0.7 and some combinations result in a peak that lies above 0.8 mark.

The spherical aberration terms vary in the combinations, from one (example: combination 77) through to the nine. In other embodiments even higher orders of spherical aberration terms may be added, to create additional combinations.

The combination 77 in the Appendix A shows that by selecting a particular level of primary spherical aberration, the aberration profile may be beneficially used for a presbyopic

eye. See US patent 6,045,568 for myopia. In contrast, according to certain embodiments, a stimulus to retard eye growth on-axis under the optical feedback explanation of emmetropisation is achieved if the retina is located on the negative side of the graph shown in Figure 65 (i.e. the focal length of the lens is longer than the eye). In other words, the aberration profile typically includes a C(2,0) term with further negative power over the amount required to correct myopia.

Appendix C lists another 67 combinations of higher order coefficients that provide both a usefully high RIQ and an option to provide an extended TF RIQ in the positive direction (right hand side of Figure 66). Also shown in Appendix C, as a point of comparison, is a combination which does not have spherical aberration of any order. The Appendix D shows the TFRIQ values for the combinations listed in Appendix C. Again, calculations were performed for a pupil size of 4 mm, however the approach, or methods, may be extended to other appropriate or desired pupil sizes, if required or desired.

The TFRIQ measures of the 67 aberration combinations are shown in Figure 66, the black line showing the symmetrical RIQ that has resulted from a combination that has no higher order aberrations, the lighter (i.e. gray) lines showing the enhanced performance in the positive direction of the TFRIQ function, for the 67 combinations that involved higher order spherical aberration terms.

From the Figure 66, a number of observations can be made. The 67 profiles with higher order spherical aberration terms provide an extended through-focus performance in the positive direction particularly when appropriate selection of a negative power is made to shift the plotted through-focus profile towards negative defocus (left). The 67 profiles include a range over which the RIQ is 0.1 or higher or greater than 2.5D. Figure 67 shows an example workflow diagram for identifying a power profile for application to a presbyopic eye, according to certain embodiments.

Section 13: Spherical aberration and astigmatism

Iterations B1, B2 and B3 have been described herein for emmetropic presbyopia. When considering the astigmatic presbyopia, at least two different methods can be adopted. A first method of correction is completed by considering astigmatic refractive error as an equivalent sphere. In this method, the spherical equivalent prescription is deduced by dividing the cylindrical/astigmatic power divided two (S = -C/2). This is a very common approach often

considered to address low to moderate amounts of astigmatism, say up to -1.5D. Once the equivalent sphere is availed, the same, or substantially the same, iterations described herein, say for example B1, B2 or B3 can be used as an effective prescription, once the defocus term is adjusted to suit the spherical equivalent.

A second method considers preparation of a toric prescription for both astigmatism and presbyopia. Figure 68 shows an exemplary embodiment that includes a toric power profile to treat both astigmatism and presbyopia. In this case, the prescription is made to correct an individual who has an astigmatic correction of -1D @ 90 and requires an additional power to enable near viewing. As can be noted from the figure, the difference between the horizontal and vertical meridian is -1D, this magnitude is set to correct the astigmatism in the above case; while the higher order spherical aberration combination is aimed to mitigate the presbyopic symptoms. Other suitable methods may also be used or incorporated into some of the disclosed embodiments.

Section 14: Implementation

Aberration profiles of the types described herein may be implemented in a number of lenses, ocular devices and/or methods. For example, contact lenses (hard or soft), corneal onlays, corneal inlays, and lenses for intraocular devices (both anterior and posterior chamber) may include the combination aberration profiles discussed. Techniques to design lenses and to achieve a power profile are known and will are not described herein in any detail. The aberration profiles can be applied to spectacle lenses. However, because the aberration profiles require alignment of the eye with the centre of the optics providing the aberration profile, then benefit may only be apparent for one particular direction of gaze. Recently electro-active lenses have been proposed that can track the direction of gaze and change the refractive properties of the lenses in response. Using electro-active lenses the aberration profile can move with the eye, which may increase the utility of the disclosed aberration profiles for spectacle lenses.

The aberration profile may be provided on a lens which is an intraocular lens. In some embodiments, the intraocular lens may include haptics that provide for accommodation. In other embodiments, the lens may have a fixed focal length. The aberration profile may be provided on a supplementary endo-capsular lens.

In certain applications, one or more of the disclosed aberration profiles may be provided

to an eye through computer-assisted surgery and/or methods of altering the power and/or aberration profile of the eye. For example implant, laser sculpting, laser abalation, thermokeratoplasty, lens sculpting are used for such a purpose. Examples of such methods include radial keratotomy (RK), photorefractive keratotomy (PRK), thermokeratoplasty, conductive keratoplasty, laser assisted in-situ keratomileusis (LASIK), laser assisted in-situ epi-keratomileusis (LASEK) and/or clear lens extraction. For example refractive surgery or corneal ablation may be used to form a selected aberration profile. The desired power profile or the desired change in corneal shape and/or power is substantially determined, or determined, and input to the laser system for application to the eye of the patient. Procedures may also be used to input a desired profile and/or aberration profile to the crystalline lens itself either by implant, laser abalation and/or laser sculpting to achieve a desired outcome. This includes, but not limited to, systems that currently exist, including wavefront guided femto-second lasers.

Where the aberration profiles are to be included in a lens, then the aberration profile may first be translated into a lens thickness profile for input to computer assisted manufacturing. Taking for example, the lens power profile D1 shown in Figure 69, which is a combination of Zernike higher order spherical aberration terms, is converted to an axial thickness, or a surface, profile for a contact lens, taking account of the refractive index of the contact lens material (in this case, contact lens material refractive index of 1.42). An example thickness profile is shown in Figure 70. In certain embodiments, features of the power or thickness profiles can either be put on the front or the back surface or a combination of both, under consideration of the refractive indices of lens and cornea. Once one or more of the following parameters, i.e., the thickness profile, power profile, back surface shape, diameter and refractive index of the material have been determined, one or more of the parameters are input to a computer assisted lathe, or other manufacturing systems to produce the contact lens. Similar approaches can be adopted for other lenses and optical systems such as intra-ocular lenses, anterior and/or posterior chamber lenses, corneal implants, refractive surgery or combinations thereof.

The aberration profile may be selected and identified as a custom lens for an individual. The process for design of the aberration profile may include measuring the wavefront aberration of the eye and designing an aberration profile to achieve a through focus RIQ profile described herein. The design process includes identifying the spherical aberration in the natural eye and designing an aberration profile for the lens, device and/or method that, in combination with the spherical aberration of the eye provides a required, or desired, RIQ profile. As described herein,

the required, or desired, RIQ profile may differ depending on the application of the lens – as different requirements may apply between, for example, a person with progressing myopia and a person with presbyopia. In some embodiments, other aberrations in the eye, for example astigmatism, coma or trefoil are ignored. In other embodiments, these are taken into account. For example, as described herein, the presence of astigmatism affects the combinations of aberrations that provide a through focus RIQ that inhibits eye growth under the optical feedback explanation of emmetropisation. In other embodiments, these aberrations are incorporated into the design. For example, when producing a lens design, a base lens may be produced that corrects for defocus and corrects one or more of astigmatism, coma and trefoil. On top of this base profile is provided a spherical aberration profile designed to achieve (in the sense of using as an objective design) the profiles described herein. The spherical aberration profile may be selected using a trial and error, or iterative-convergence approach, for example by identifying a candidate profile, computing the through focus RIQ and evaluating whether the through focus RIQ has an acceptable profile. In another approach aberration profiles may be designed for population average, mean, median or other statistical representations or metrics. One approach for designing population average, mean, median or other statistical representations or metrics, lenses is to normalise, or customise, or tailor, or optimise, the design for a pupil size.

In certain embodiments, the description of the aberration profiles, first derivatives of the power profiles, second derivatives of the power profiles, Fourier transformation of the power profiles, power profiles and image profiles of the power profiles and/or other suitable or appropriate measures of one or more optical characteristics or one or more performance metrics for lenses, devices and/or methods has been provided to some extent by way of mathematical explanation or derivation. This allows to some extent for precision in deriving and/or describing the aberration profiles, first derivatives of the power profiles, second derivatives of the power profiles, Fourier transformation of the power profiles, power profiles and image profiles of the power profiles for lenses.

However, in certain applications, lenses, devices and/or methods may or may not have precision that is comparable to, or commensurate with or derived from the mathematical calculations. For example tolerances and inaccuracies arising during manufacture may or may not result in variations of the lens profile. In certain embodiments, the power profile and/or aberration profile of a lens may be approximately measured using, for example, a wavefront aberrometer. From this an approximate measure of through focus RIQ may be determined; for

example, using Visual Strehl Ratio. In certain embodiments, the power profile and/or aberration profile of a lens may be characterised by using, for example, suitable instruments and/or techniques such as Hartman-Shack aberrometry, ray-tracing, lens power mapping, focimetry, interferometry, phase contrast, ptchyography, Foucault knife-edge systems, or combinations thereof. From these characterisations one or more of the following: aberration profiles, first derivatives of the power profiles, second derivatives of the power profiles, Fourier transformation of the power profiles, power profiles and image profiles of the power profiles and/or other suitable or appropriate measures of one or more optical characteristics or one or more performance metrics, may be measured, derived or otherwise determined.

Aberration profiles may be implemented in a number of lenses, devices and/or methods, according to certain embodiments. For example, the lens may be characterised by testing the lens on a ray tracing or physical model eye with a focal length equal to, or substantially equal to, the focal distance of the lens. The aberration profile of the lens, including higher order aberration profiles, that would result in a image on the retina which may be quantified using one or more of the RIQ metrics disclosed. In certain embodiments, the model eye may have no, or substantially no, aberrations. In certain embodiments, the RIQ metric may be visual Strehl ratio. In other embodiments, the pupil size may be selected from one or more of the following ranges: 2 to 8 mm, 2 to 7 mm, 2 to 6 mm, 3 to 6 mm, 3 to 5 mm, 4 to 6 mm or 5 to 7 mm. In some other embodiments, the spatial frequency ranges can be selected from one of the following: 0 to 30 cycles/degree, 0 to 60 cycles/degree or 0 to 45 cycles/degree. In other embodiments, the selected wavelength for calculations of one or more RIQ metrics may be selected from one or more of the following: 540 nm to 590 nm inclusive, 420 nm to 760 nm inclusive, 500 nm to 720 nm inclusive or 420 nm to 590 nm inclusive. In certain embodiments, the RIQ may be measured on an on-axis model eye. In other applications an off-axis model eye may be used to obtain other RIQ variants like the global RIQ. The through-focus RIQ may be calculated on the model eye by using spherical lenses in front the model eye.

Certain embodiments disclosed herein are directed to methods of correcting vision whereby a lens of one or more of the disclosed embodiments is prescribed according to one or more target refractive powers, an appropriate power profile, and the lens is fitted to an eye to provide a visual performance for the eye, along a range of substantially continuous visual distances, including intermediate and far distances, wherein the visual performance of the lens is at least substantially equivalent to the visual performance of a correctly prescribed single-vision

lens at the far visual distance. Certain embodiments disclosed herein are directed to methods of correcting vision whereby a lens of one or more of the disclosed embodiments is prescribed according to one or more target refractive powers, an appropriate power profile, and the lens is fitted to an eye to improve the visual performance for the eye. In certain applications, one or more methods disclosed herein may be used for correcting vision of the eye according to certain embodiments, whereby the eye is affected by one or more of the following: myopia, hyperopia, emmetropia, astigmatism, presbyopia and optically aberrated.

Certain embodiments, may be used in methods for correcting the vision of a pair of eyes, whereby one or both of the eyes is optically aberrated possesses at least one higher-order aberration. Certain embodiments, may be used in methods of correcting binocular vision, whereby two lenses of one or more embodiments disclosed herein are prescribed according to a first and a second target refractive power, a first and a second power profile are selected, and the two lenses fitted to a pair of eyes improve the visual performance of the two eyes combined compared to individual eyes separately. In certain methods disclosed herein, the first target refractive power is different from the second target refractive power.

Certain embodiments are directed to methods of correcting binocular vision, whereby the first target refractive power is selected to improve visual performance at a visual distance that is at least one of the following: far, intermediate, near; and the second target refractive power is selected to improve visual performance at a visual distance that is at least one of the following: far, intermediate, near; wherein the visual distance at which the visual performance for which the first target refractive power is selected is different from the visual distance at which the visual performance for which the second target refractive power is selected. In certain applications, one or more methods disclosed herein may be used for correcting vision of the eye according to certain embodiments, whereby the refractive state of the eye may be classified as one or more of the following: myopia, hyperopia, emmetropia, regular astigmatism, irregular astigmatism, optically aberrated, presbyopia, non-presbyopia.

Certain embodiments are directed to methods of manufacturing lenses where the lenses are configured or designed according to a reference eye, whereby the lens features that are configured are selected from one or more of the following: focal length, refractive power, power profile, number of spherical aberration terms, magnitude of spherical aberration terms; whereby the reference eye is selected from one or more of the following: an individual eye, both eyes of

an individual person, statistical representation of eyes a sample of an affected population, computational model of an eye and/or computational model of eyes of an affected population.

In certain embodiments, aperture size may be used to characterise an entrance pupil of the eye and/or a portion of the optic zone of a lens and/or device. In certain applications, the effective aperture size maybe defined as an opening that is greater than or equal to 1.5 mm, 2 mm, 3 mm, 4 mm, 5 mm, 6 mm or 7 mm, this is in contrast to pin-hole apertures which typically have a diameter, for example, less than 1.5 mm. For example, certain embodiments are directed to a lens comprising: an optical axis; at least two optical surfaces; wherein the lens is configured to provide a visual performance on a presbyopic eye substantially equivalent to the visual performance of a single-vision lens on the pre-presbyopic eye; and wherein the lens has an aperture size greater than 1.5 mm.

Certain embodiments are directed to one or more methods of surgical correction of vision to improve visual performance. For example, a method for surgical correction may comprise the steps of: (1) computing one or more targeted modifications to the optical properties, power and/or physical structure of an eye; wherein the targeted modifications comprise: at least one desired refractive power and at least one appropriate power profile; at least one aberration profile, wherein the aberration profile is comprised of at least two spherical aberration term and a defocus term; and a visual performance along substantially continuous visual distances including near, intermediate and far, wherein the visual performance of the eye along the substantially continuous visual distance is substantially equivalent to the visual performance of an eye wearing an correctly prescribed single-vision lens for the far visual distance; (2) inputting the desired modifications to an ophthalmic surgical system; and (3) applying the desired modifications to the eye with the ophthalmic surgical system. In certain applications, the visual performance of the eye is further characterised by minimal, or no, ghosting at near, intermediate and far visual distances.

In certain applications, the vision performance of the correctly prescribed single vision lens provides a visual acuity for the eye that is the best-corrected visual acuity. In certain applications, the best-corrected visual acuity is a visual acuity that cannot be substantially improved by further manipulating the power of the correctly prescribed single vision lens. In certain applications, the aberration profile comprises three or more spherical aberration terms and a defocus term.

Certain embodiments are directed to lenses that provide substantially equivalent, or equivalent or better optical and/or visual performance than a correctly prescribed single vision lens at far visual distance. As used in certain embodiments, correctly prescribed may mean a prescribed single vision lens at the far visual distance that provides a visual acuity for an eye that is the best-corrected visual acuity and cannot be substantially improved by further manipulating or adjusting the power of the lens. As used in certain embodiments, appropriately, properly, effectively, prescribed may mean a prescribed single vision lens at the far visual distance that provides a visual acuity for an eye that approximates the best-corrected visual acuity and cannot be substantially improved by further manipulating or adjusting the power of the lens.

Certain embodiments are directed to one or more methods of surgical correction of vision to improve visual performance. For example, a method of correcting vision comprising the steps of: (1) computing one or more targeted modifications to an eye; wherein the modifications provides to the eye: at least one optical characteristic; wherein the at least one optical characteristic comprises at least one aberration profile; the aberration profile comprises at least two spherical aberration term and a defocus term; and a visual performance at intermediate and far visual distances that is at least substantially equivalent to the eye fitted with an correctly prescribed single-vision lens for far visual distance; wherein when tested with a defined visual rating scale of 1 to 10 units, the visual performance of the eye at the near visual distance is within two units of the visual performance of the eye fitted with an correctly prescribed single-vision lens at far distance; (2) inputting the desired modifications to an ophthalmic surgical system; and (3) applying the targeted modifications to the eye with the ophthalmic surgical system. In certain applications, the visual performance additionally provides substantially minimal ghosting to the vision of the eye at near, intermediate and far visual distances. In certain applications, the substantially equivalent to or better visual performance is determined at least in part by a visual rating scale of 1 to 10 units.

Certain embodiments are directed to one or more methods of surgical correction of vision to improve visual performance. For example, methods of vision correction may comprise the steps of: (1) computing one or more targeted modifications to an eye; wherein the modifications provide to the eye: at least one optical characteristic; wherein the at least one optical characteristic comprises at least one aberration profile; the aberration profile comprises at least two spherical aberration term and a defocus term; and a visual performance at intermediate and far visual distances, that is substantially equivalent to, or better than, the eye fitted with a

correctly prescribed single-vision lens for far visual distance; and wherein the visual performance is further characterised by minimal ghosting to the vision of the eye at least at far distance; (2) inputting the desired modifications to an ophthalmic surgical system; and (3) applying the desired modifications to the eye with the ophthalmic surgical system. In certain applications, the minimal ghosting is attaining a score of less than or equal to 2.4, 2.2, 2, 1.8, 1.6 or 1.4 on the vision rating ghosting scale of 1 to 10 units.

Certain embodiments are directed to one or more devices and/or systems for the surgical correction of vision to improve visual performance. For example, a device and/or system for correcting vision of an eye may comprise: (1) an input module; (2) a computation module; and (3) a delivery module; wherein the input module is configured to receive input relevant to the vision correction of the eye; the computation module is configured to compute one or more targeted modifications to the eye; wherein the modifications provides to the eye: at least one targeted refractive power and at least one appropriate power profile; at least one aberration profile, wherein the aberration profile being comprised of at least two spherical aberration term and a defocus term; and a visual performance, along substantially continuous visual distances, including intermediate and far, wherein the visual performance of the eye along the substantially continuous visual distance is substantially equivalent to the visual performance of an eye wearing an correctly prescribed single-vision lens for the far visual distance; and the delivery module uses the computed targeted modifications to the eye computed by the computation module to deliver the targeted modifications to the eye. In certain applications, the visual performance of the eye is further characterised by minimal, or no, ghosting at near, intermediate and far visual distances.

In certain applications, the correctly prescribed single vision lens provides a visual acuity for the eye that is the best-corrected visual acuity. In certain applications, the best-corrected visual acuity is a visual acuity that cannot be substantially improved by further manipulating the power of the correctly prescribed single vision lens. In certain applications, the aberration profile comprises three or more spherical aberration term and a defocus term. In certain applications, the delivery module may be an ophthalmic refractive surgical system such as a femto-second laser.

Certain embodiments are directed to one or more devices and/or systems for the surgical correction of vision to improve visual performance. For example, a device and/or system for correcting vision of an eye may comprise: (1) an input module; (2) a computation module; and

(3) a delivery module; wherein the input module is configured to receive input relevant to the vision correction of the eye; the computation module is configured to compute one or more desired modifications to the eye; wherein the modifications provides to the eye: at least one optical characteristic; wherein the at least one optical characteristic comprises at least one aberration profile; the aberration profile comprises at least two spherical aberration term and a defocus term; and a visual performance at intermediate and far visual distances that is substantially equivalent to or better than the eye fitted with an correctly prescribed single-vision lens for far visual distance; and when tested with a defined visual rating scale of 1 to 10 units, the visual performance of the eye at the near visual distance is within two units of the visual performance of the eye fitted with an correctly prescribed single-vision lens at far distance; the delivery module utilising desired modifications to the eye computed by the computation module to deliver the desired modifications to the eye.

In certain applications, the visual performance in addition, provides minimal ghosting to the vision of the eye at near, intermediate and far visual distances. In certain applications, the substantially equivalent to or better visual performance is substantially determined at least in part by a visual rating scale of 1 to 10 units. In certain applications, the delivery module is an ophthalmic refractive surgical system such as a femto-second laser.

Certain embodiments are directed to one or more devices and/or systems for the surgical correction of vision to improve visual performance. For example, a device and/or system for correcting vision of an eye may comprise: (1) an input module; (2) a computation module; and (3) a delivery module; wherein the input module is configured to receive input relevant to the vision correction of the eye; wherein the computation module is configured to compute one or more targeted modifications to the eye; wherein the modifications provides to the eye: at least one optical characteristic; wherein the at least one optical characteristic comprises at least one aberration profile; wherein the aberration profile comprises at least two spherical aberration terms and a defocus term; and a visual performance at intermediate and far visual distances, that is substantially equivalent to, or better than, the eye fitted with a correctly prescribed single-vision lens for far visual distance; and wherein the visual performance is characterised by minimal ghosting to the vision of the eye at least at far distance; and the delivery module utilising the computed targeted modifications to the eye computed by the computation module to deliver the desired modifications to the eye.

In certain applications, the minimal ghosting has a score of less than or equal to 2.4, 2.2, 2,

1.8, 1.6 or 1.4 on the vision rating ghosting scale of 1 to 10 units. In certain applications, the delivery module is an ophthalmic refractive surgical system such as a femto-second laser.

In certain embodiments, the lens is configured to provide vision substantially equivalent, or better, to distance vision corrected with a correctly prescribed lens for the refractive error for distance across a dioptric range of 0D to 2.5D or from infinity to 40cm with minimal ghosting for emmetropes, myopes, hyperopes and astigmats.

In certain applications, the lenses substantially correct the distance refractive error; wherein the lens is configured to enable myopia to be slowed without the loss of vision as is usually associated with multifocal contact lenses and provides excellent vision across the visual field for example, 30 degrees nasal to 30 degrees temporal and also allows the provision of lenses that give retinal image quality of 0.4 or above for either a chosen focal distance or averaged across focal distances from infinity to 40cm with an average of 0.3 retinal image quality. Such lenses when optimising retinal image quality provide exceptionally clear high contrast images at the chosen distances; wherein the lens provides exceptional image quality and visual performance with minimal ghosting across the range of dioptric distances from infinity to near for the correction of refractive errors and treatment of presbyopia and myopia control; when tested with a defined overall visual rating scale of 1 to 10 units, the multifocal lens is configured such that the overall visual performance of the multifocal lens is substantially equivalent to or better than an correctly prescribed single-vision lens for far visual distance.

In certain embodiments, the visual performance of a candidate eye, along a range of substantially continuous visual distances, including near, intermediate and far distances, wherein the visual performance of the multifocal lens is at least substantially equivalent to the visual performance of a correctly prescribed single-vision lens at the far visual distance.

In certain embodiments, the term minimal ghosting may mean a lack of an undesired secondary image appearing at the image plane of the optical system. In certain embodiments, the term minimal ghosting may be used to represent an undesired secondary image appearing on the retina of the eye. Conversely, the term lack of ghosting may represent an undesired double image appearing on the retina of the eye. In certain embodiments, minimal ghosting may represent a lack of an undesired double image perceived by the candidate eye. In other applications, minimal ghosting represents a lack of false out-of-focus image appearing along side of the primary image in an optical system.

Section 15: Exemplary sets of lens designs which are substantially independent of Inherent spherical aberration of the eye

The interactions between the inherent aberration profiles of the candidate eyes and those of a selected combination of a design set may have a) an improved effect; b) degraded effect; or c) no substantial effect on the objective and/or subjective optical and/or visual performance.

The present disclosure provides embodiments directed to choosing between a positive and/or negative phase of a particular combination of aberration profile to be able to attain a specific goal for the candidate eye. The specific goal for instance may be to change the slope of through-focus RIQ in the direction that would favour the emmetropisation process for myopic or hyperopic eyes; or alternatively similar approach, or methods, may be used to mitigate the presbyopic symptoms in alternative candidate eyes.

Certain embodiments are directed to a lens, device and/or method that enables the designing of lenses which when applied to a candidate eye may produce a visual performance that is substantially independent of the aberration profile of that candidate eye. Substantially independent, in certain applications, means that lenses may be designed that provide acceptable and/or similar performance on a plurality of candidate eyes that are within the representative sample of the target populations.

In certain applications, methods to obtain a target TFRIQ include use of a non-linear, unconstrained optimization routine and one or more other variables. The variables selected for the non-linear, unconstrained, optimisation routine may include a chosen group of Zernike spherical aberration coefficients, from C (2, 0) to C (20, 0) and one or more other variables. The other variables, for example, may be aberration profiles of a representative sample of the target population.

Lenses may be designed by selecting an optimisation routine to evaluate a through-focus RIQ may include: a) a target TFRIQ; b) a target TFRIQ within predefined bounds; or c) combination of a) and b). Iteration G1 (Figure 71) is one exemplary of a lens design whose visual performance is independent of the inherent aberration profile of the candidate eye.

Table 13 provides the defocus term and the rest of combinations of spherical aberration terms, denoted in Zernike coefficients C(2,0) to C(20,0), that represents the exemplary design at 4, 5 and 6 mm optic zone or pupil diameter.

Iteration G1	At 4 mm	At 5 mm	At 6 mm
C(2,0)	0.442	0.558	0.47
C(4,0)	-0.103	-0.096	-0.241
C(6,0)	-0.081	0.038	0.038
C(8,0)	0.032	0.017	0.046
C(10,0)	0.056	-0.086	0.043
C(12,0)	-0.017	-0.027	0.057
C(14,0)	-0.023	0.053	-0.056
C(16,0)	0.01	-0.005	-0.053
C(18,0)	0.004	-0.017	0.051
C(20,0)	-0.002	0.017	0.006

Table 13 Defocus and higher order spherical aberration coefficients, at 4, 5 and 6 mm optic zone diameter, of an exemplary embodiment whose performance is substantially independent of the inherent spherical aberration of the candidate eye for at least at 4 and 5 mm pupil diameters of the candidate eye.

Figure 72 shows a graph of the through focus performance of Iteration G1 for a 4 mm pupil size, for a range of inherent spherical aberration ranging from -0.1 μm to +0.2 μm (and no other inherent aberrations). Figure 73 shows the corresponding performance for a 5 mm pupil size. For both the through focus performance is relatively constant despite variations in inherent spherical aberration. Accordingly, lenses of Iteration G1 lenses with aberration profiles of similar characteristics may be prescribed to a relatively large number of recipients in a population. The through focus performance of Iteration G1 for both 5 mm and 4 mm pupil sizes are shown in Tables 14, 15, 16 and 17 for inherent primary spherical aberration of -0.10 μm, 0.00 μm, +0.10 μm and +0.20 μm, respectively, all measured assuming a 5 mm pupil.

Defocus	**4 mm**	**5 mm**
-2.5	0.00119886	0.003061423
-2.25	0.00095039	0.003806875
-2	0.001364417	0.005298066
-1.75	0.001742406	0.006843299
-1.5	0.001679323	0.010835082
-1.25	0.00192035	0.01830825

-1	0.013520284	0.032178724
-0.75	0.065302521	0.060184893
-0.5	0.173998496	0.121126561
-0.25	0.293118842	0.216544389
0	0.339358737	0.336047586
0.25	0.308917813	0.44319587
0.5	0.296642047	0.451905679
0.75	0.347950208	0.378483458
1	0.408879749	0.322335542
1.25	0.427748471	0.304996424
1.5	0.37817358	0.291026543
1.75	0.269892513	0.249490988
2	0.163901919	0.182309343
2.25	0.096322599	0.115370704
2.5	0.057024345	0.066978954

Table 14: The through focus performance of Iteration G1, for both 5 mm and 4 mm pupil sizes, on candidate eye with an inherent primary spherical aberration C (4,0) of -0.10 μm of the candidate eye measured at 5 mm pupil.

Defocus	4 mm	5 mm
-2.5	0.002187878	0.004298075
-2.25	0.002540196	0.004586267
-2	0.003374035	0.005323423
-1.75	0.003960812	0.006382736
-1.5	0.005219352	0.008271293
-1.25	0.006557495	0.014973531
-1	0.011219528	0.0302146
-0.75	0.036451401	0.063248601
-0.5	0.115450661	0.130914147
-0.25	0.267210472	0.245890777
0	0.423804424	0.360586104
0.25	0.46403645	0.436398077
0.5	0.39835734	0.491624785
0.75	0.367734797	0.487505993
1	0.397654136	0.416666845
1.25	0.39125203	0.332643018
1.5	0.32027978	0.25244515
1.75	0.221249807	0.176653138
2	0.131992993	0.109872181
2.25	0.074288941	0.062381228
2.5	0.040188833	0.0351223

Table 15: The through focus performance of Iteration G1, for both 5 mm and 4 mm pupil sizes, on candidate eye with an inherent primary spherical aberration C (4,0) of 0.00 μm of the candidate eye measured at 5 mm pupil.

Defocus	4 mm	5 mm
-2.5	0.003390339	0.006013951
-2.25	0.004186307	0.006637962
-2	0.005762618	0.00779601
-1.75	0.006575919	0.009656762
-1.5	0.008393696	0.014689142
-1.25	0.012657589	0.025629807
-1	0.022035399	0.047996025
-0.75	0.046157477	0.090294111
-0.5	0.104516622	0.165591385
-0.25	0.236547956	0.27588147
0	0.431420876	0.386563827
0.25	0.551884107	0.428024189
0.5	0.496190837	0.438984315
0.75	0.386699104	0.49976799
1	0.363362176	0.494007104
1.25	0.355116147	0.361435685
1.5	0.281805872	0.217793731
1.75	0.187900702	0.119838537
2	0.11184446	0.060218079
2.25	0.058787	0.029374264
2.5	0.027932205	0.015204204

Table 16: The through focus performance of Iteration G1, for both 5 mm and 4 mm pupil sizes, on candidate eye with an inherent primary spherical aberration C (4,0) of 0.10 μm of the candidate eye measured at 5 mm pupil.

Defocus	4 mm	5 mm
-2.5	0.004638912	0.007979577
-2.25	0.005633686	0.009519564
-2	0.007793299	0.012695114
-1.75	0.009270616	0.018089081
-1.5	0.011895079	0.029157339
-1.25	0.019319329	0.048941178
-1	0.035179393	0.079799998
-0.75	0.06730507	0.129064657
-0.5	0.122863955	0.204557522
-0.25	0.230284041	0.30140315
0	0.408582384	0.384829646
0.25	0.560957635	0.41511762
0.5	0.546063168	0.392578625
0.75	0.412352839	0.410254281
1	0.338981707	0.472977562
1.25	0.326435368	0.406675013
1.5	0.263875392	0.22704487
1.75	0.170102388	0.09758611
2	0.098903445	0.039837893
2.25	0.049625854	0.014206731
2.5	0.020526457	0.003763349

Table 17: The through focus performance of Iteration G1, for both 5 mm and 4 mm pupil sizes, on candidate eye with an inherent primary spherical aberration C (4,0) of 0.20 μm of the candidate eye measured at 5 mm pupil.

Section 16: Exemplary sets of designs as Intra-Ocular lenses

Aberration profiles may be used in intra-ocular lens applications, according to certain embodiments. For example, the aberration profile, and/or power profile, may be translated into an intra-ocular lens surface profile, using one or more of the following parameters: thickness profile, power profile, aberration profile, front surface, back surface, diameter, and/or refractive index of the material. The surface profile is thereafter provided to a computer assisted or other manufacturing process to produce the intra-ocular lens. The intra-ocular lens produced is configured based at least in part on the surface profile and/or surface profiles generated. The lens power profile (Iteration J1) shown in Figure 74 is a combination of Zernike higher order spherical aberration terms. The power profile may be converted to an axial thickness profile (Figure 75) for an intra-ocular lens, taking into account the refractive index of the intra-ocular lens material, according to certain embodiments. Here, the refractive index of intra-ocular lens material is 1.475. Table 18 provides the defocus term and other combinations of spherical aberration terms, denoted in Zernike coefficients C(2,0) to C(20,0), that represent an exemplary design of an intra-ocular lens (Figure 74) at 4 and 5 mm optic zone diameter.

Iteration J1										
Optic zone or Pupil size	C(2,0)	C(4,0)	C(6,0)	C(8,0)	C(10,0)	C(12,0)	C(14,0)	C(16,0)	C(18,0)	C(20,0)
At 4 mm	12.060	-0.120	-0.085	0.033	0.058	-0.018	-0.023	0.012	0.005	-0.003
At 5 mm	18.666	-0.129	0.040	0.018	-0.089	-0.026	0.056	-0.006	-0.019	0.017

Table 18 Defocus and higher order spherical aberration coefficients, at 4, and 5 mm optic zone diameter or pupil size, for one of the exemplary embodiment of an intra-ocular lens design that provides an improvement in the through-focus optical and/or visual performance of the candidate eye.

Section 17: Descriptors for power profiles with use of a Fourier Transform

Fourier transform methods may be used to characterise the power profiles of certain embodiments and in particular for certain bifocal or multifocal designs. For example, Figure 76 plots the power profiles for a number of commercially available bifocal and multifocal lenses. Figure 77 plots the power profiles for a number of bifocal or multifocal lenses according to embodiments. Figure 78 plots the Fourier transform of the power profiles for the commercially available bifocal and multifocal lenses of Figure 76. Figure 79 plots Fourier transforms of power profiles of Figure 77. For both Figures 78 and 79, the horizontal axis represents spatial frequency in cycles per millimetre (cycles/mm) and the vertical axis plots the normalised absolute of the amplitude spectrum from the fast Fourier transform of the power profiles. In these figures, normalised means rescaling of each amplitude spectrum so that the maximum value for the absolute of an amplitude spectrum is rescaled to 1. For example, the normalised absolute of the amplitude spectrum may be obtained by dividing the absolute of amplitude spectrum by the maximum value of the absolute of amplitude spectrum.

A comparison of Figures 78 and 79 illustrate differentiation between certain embodiments and the plotted commercially available lenses, as their normalised absolute amplitude of the Fourier transform of their power profiles has normalised absolute amplitude greater than 0.2 at one or more spatial frequencies at or above 1.25 cycles per millimetre. In contrast to the illustrated embodiments Figures 77 and 79, none of the currently available commercial lenses have normalised absolute amplitude greater than 0.2 at one or more spatial frequencies at or above 1.25 cycles per millimetre. Certain embodiments such as lenses, bifocal lenses, and/or multifocal lenses may be characterised using Fourier transform. For example, certain embodiments are directed to a lens comprising: an optical axis; at least two surfaces; wherein the lens is characterised by a power profile that has a normalised absolute amplitude of the Fourier transform of the power profile that is greater than 0.2 at one or more spatial frequencies at or above 1.25 cycles per millimetre. In certain applications, the lens is configured with a power profile that has a normalised absolute amplitude of the Fourier transform of the power profile that is greater than 0.2 at one or more spatial frequencies at or above 1.25 cycles per millimetre.

Section 18: Descriptors of power profiles using first derivatives or rate of change of power

First derivatives methods may be used to characterise the power profiles of certain embodiments, and in particular, for certain bifocal or multifocal designs. For example, Figure 76 plots the power profiles for a number of commercially available bifocal and multifocal lenses. Figure 77 plots the power profiles for a number of multifocal lenses according to embodiments. Figure 80 plots the first derivative of the power profiles for the commercially available bifocal and multifocal lenses of Figure 76. Figure 81 plots the first derivative of power profiles of Figure 77. For both Figures 80 and 81, the horizontal axis represents half-chord of the optic zone diameter and the vertical axis plots the absolute of the first derivative of the power profiles.

A comparison of Figures 80 and 81 illustrates differentiation between certain embodiments and the plotted commercially available lenses, as the absolute of the first derivative of the power profiles of the illustrated embodiments have at least 5 peaks whose absolute amplitude is greater than 0.025 with units of 1D per 0.01 mm. In contrast to the illustrated embodiments Figures 80 and 81, none of the currently available commercial lenses have at least 5 peaks with absolute first derivative greater than 0.025 with units of 1D per 0.01 mm.

Certain embodiments such as lenses, bifocal lenses, and/or multifocal lenses may be characterised using first derivative or rate of change of power. For example, certain embodiments are directed to a lens comprising: an optical axis; at least two surfaces; wherein the lens has a power profile, the power profile is characterised such that the absolute of a first derivative of the power profile has at least 5 peaks whose absolute amplitude is greater than 0.025 with units of 1D per 0.01 mm along its half-chord. In certain applications, the at least one power profile is characterised such that the absolute of a first derivative of the power profile has at least 5 peaks whose absolute amplitude is greater than 0.025 with units of 1D per 0.01 mm along its half-chord.

Section 19: Descriptors of power profiles with use of aperiodic functions

Certain embodiments of the present disclosure have one or more power profiles that may be characterised by aperiodic functions over a substantial portion of the half-chord optical zone of the lens. Certain embodiments are directed to lenses that are configured such that the at least one power profile is aperiodic over a substantial portion of the half-chord optical zone of the

lens. In general terms, an aperiodic function is defined as a function that is not periodic. A periodic function is a function that repeats or duplicates its values in regular intervals, often denoted as periods. For example, trigonometric functions (i.e. sine, cosine, secant, cosecant, tangent and cotangent functions) are periodic as their values are repeated over intervals of 2π radians. A periodic function can also be defined as a function whose graphical representation exhibits translational symmetry. A function F(x) is said to be periodic with a period P (where P is a non-zero constant), if it satisfies the following condition: $F(x+P) = F(x)$.

Section 20: Descriptors of power profiles with use of non-monotonic functions

Certain embodiments of the present disclosure have one or more power profiles that may be characterised by non-monotonic functions over a substantial portion of the half-chord optical zone of the lens. Certain embodiments are directed to lenses that are configured such that the at least one power profile is non-monotonic over a substantial portion of the half-chord optical zone of the lens. In general terms, a 'monotonic' or 'monotone' function is a function which either is substantially non-increasing or substantially non-decreasing. A function F(x) is said to be non-increasing on an interval I of real numbers if: $F(b) <= F(a)$ for all $b>a$; where a, b are real numbers and are a subset of I; A function F(x) is said to be non-decreasing on an interval I of real numbers if: $F(b) >= F(a)$ for all $b>a$; where a, b are real numbers and are a subset of I.

Section 21: Descriptors of power profiles with use of non-monotonic and aperiodic functions

Certain embodiments of the present disclosure have one or more power profiles that may be characterised by non-monotonic and aperiodic functions over a substantial portion of the half-chord optical zone of the lens. Certain embodiments are directed to lenses that are configured such that the at least one power profile is non-monotonic and aperiodic over a substantial portion of the half-chord optical zone of the lens. In general, some functions may be both non-monotonic and aperiodic. Such functions possess properties of both non-monotonic and aperiodic function as described herein.

Certain embodiments such as lenses, bifocal lenses, and/or multifocal lenses may be characterised using aperiodic function, non-monotonic function, or combinations thereof. A lens comprising: an optical axis; at least two surfaces; wherein the lens has at least one power profile, the power profile is characterised by a function that is non-monotonic, aperiodic or combinations

thereof over a substantial portion of the half-chord optical zone of the lens. In certain applications, the lens is configured with a power profile that is non-monotonic, aperiodic or combinations thereof over a substantial portion of the half-chord optical zone of the lens.

Section 22: Power profile

As is apparent from a visual inspection of at least Figures 19, 20, 22-25, 29, 31, 34, 35, 39, 40, 41, 56-60 and 68, certain embodiments have a power profile that has the following combination of characteristics across half-chord diameters:

(i) A power profile that has a moving average that either increases with diameter and then decreases, or decreases with diameter and then increases. For certain contact lens embodiments, the moving average may be calculated over a window of 1 mm from on-axis to about 4 mm. Accordingly, by way of example, the average value may be calculated across the range of on-axis to 1mm, and recalculated at intervals selected from the group of 0.2 mm, 0.4 mm or 0.6 mm.

(ii) A power profile that transitions between local minima and maxima within a 1 mm change of radius at least 4 times across 4 mm of the half-chord. For example, referring to Figure 22, the power profile starts at a local maximum on-axis and transitions to a local minimum at about 1 mm radius; the transitions between local maxima and minima then occur at about 1.6 mm and about 2.3 mm. After that, the power profile may either have the next local minima at about 2.9 mm, a local minimum at about 3.1 mm and a local maximum at about 4 mm, or have the next local maximum at about 4 mm. In some examples, the power profile transitions at least 6 times across a 4 mm of the half-chord. For example, referring to Figure 24, there are two transitions in the first 1 mm radius, two in the second 1mm radius, and two transitions in the region from 2 mm to 4 mm. In some examples the power profile transitions at least 8 times across the 4 mm radius range (for example Figure 29) or at least 12 times across the 4 mm radius range (for example Figure 35) or at least 15 times (for example Figure 40).

(iii) The power profile transitions smoothly out to a radius selected from the group of at least 3 mm, at least 3.5 mm and at least 4 mm.

Accordingly, certain embodiments have a power profile with a combination selected from the options within (i) and (ii) and (iii), which provides acceptable vision for at least a subset of a

population. These embodiments may have application to myopia, hyperopia, and/or presbyopia, with or without astigmatism. Other embodiments include a combination from the options described above in this section 22, together with one or more of:

(iv) The refractive power on-axis power differs from the prescription power by at least about 0.7D (e.g. see Figure 22), or by at least about 1.5 D (e.g. see Figure 38).

(v) The difference between the global maximum and global minimum power is between approximately 1.5 to 2.5 times the difference between any adjacent local minimum and local maximum within a radius of about 2.5 mm. In other words, the global maximum and global minimum are reached through a stepped change in power profile, that itself transitions between local minima and local maxima.

It is understood that, due to differences in aperture size, refractive index of the material and refractive index of the environment, that certain parameters may change for implementation across different lenses, devices and methods. For example, the parameters may change between embodiments in the form of contact lenses and equivalent embodiments in the form of intraocular lenses.

Section 23: Clinical performance of some exemplary embodiments compared with commercially available single vision, bifocal and multifocal soft contact lenses.

In the following experimental clinical study, performance of four exemplary embodiments described herein (manufactured into the form of soft contact lenses) were compared against seven commercially available lenses including one single vision, one bifocal and five multifocal products whose details are provided in the table herein, Table 19. The study was approved by ethics committee of Bellberry, South Australia.

Experimental purpose:

The aim of the study was to assess the visual performance of four multifocal soft contact lenses, according to certain embodiments, and six commercially available bifocal and multifocal lens designs.

Study Design:

The study design was a prospective, participant-masked, bilateral wear, cross-over clinical trial with a minimum overnight washout period between the lens assessments. Lens wear

duration was up to 2 hours.

Participant Selection:

Participants were included in the study if they met the following criterion:

a) Able to read and comprehend English and give informed consent as demonstrated by signing a record of informed consent.

b) Be at least 18 years old, male or female (the results reported herein are for participants over 45 years).

c) Willing to comply with the wearing and clinical trial visit schedule as directed by the Investigator.

d) Have ocular health findings within normal limits which would not prevent the participant from safely wearing contact lenses.

e) Is correctable to at least 6/6 (20/20) or better in each eye with single vision contact lenses.

f) Have an astigmatism correction of -1.5 D or less.

g) Be experienced or inexperienced at wearing contact lenses.

Participants were excluded from the study if they had one or more of the following conditions:

a) Pre-existing ocular irritation, injury or condition (including infection or disease) of the cornea, conjunctiva or eyelids that would preclude contact lens fitting and safe wearing of contact lenses.

b) Systemic disease that adversely affected ocular health e.g. diabetes, Graves disease, and auto immune diseases such as ankylosing spondylitis, multiple sclerosis, Sjögrens syndrome and systemic lupus erythematosus. Note: Conditions such as systemic hypertension and arthritis would not automatically exclude prospective participants.

c) Use of or a need for concurrent category S3 and above ocular medications at enrolment and/or during the clinical trial.

d) Use of or a need for systemic medication and/or topical medications which may alter normal ocular findings and/or are known to affect a participant's ocular health and/or physiology or contact lens performance either in an adverse or beneficial manner at enrolment and/or during the clinical trial.

e) NB: Systemic antihistamines are allowed on an "as needed basis", provided they are not

used prophylactically during the trial and at least 24 hours before the clinical trial product is used.

f) Eye surgery within 12 weeks immediately prior to enrolment for this trial.

g) Previous corneal refractive surgery.

h) Contraindications to contact lens wear.

i) Known allergy or intolerance to the ingredients of the clinical trial products.

j) The investigators excluded anyone who they believe may not be able to fulfil the clinical trial requirements.

Methods:

For each fitting visit, lenses were fitted bilaterally. After allowing for the lenses to settle, lens performance was assessed including:

1. Visual acuity
   a. Log MAR charts were used to obtain measurements for vision at distance under high illumination conditions
   b. High contrast visual acuity at 6 metres
   c. Low contrast visual acuity at 6 metres
   d. Contrast sensitivity using a Pelli-Robson equivalent chart (using Thomson software) equivalent at 6 metres, the text was kept constant at 6/12 letter size while the contrast was reduced as a logarithmic function.
   e. Hanks near point chart was used to measure visual acuity at 70 cm (intermediate vision), at 50 cm and 40 cm (near vision) under high illumination conditions. As the Hanks near point chart was designed to be used at 40 cm near, the visual acuity equivalents for 50 cm and 70 cm were calculated. Both intermediate and near visual acuity results were converted to equivalent log MAR

Lens Code	*Contact Lenses (Marketed in Australia as)*	*Manufacturer*	*Material*	*Mode of Wear in this Trial*	*Power (D)*	*Diameter (mm)*	*Base Curve (mm)*
Lens A	AirOptix® Aqua Single vision	Alcon (USA)	Lotrafilcon B	Daily wear	+4.00D to -10.00	14.2	8.6
Lens B	Air Optix® Aqua Multifocal	CIBA VISION (USA)	Lotrafilcon B	Daily Wear	+6.00D to -1.00D Low/Med/High	14.2	8.6
Lens C	ACUVUE® Bifocal	J&J (USA)	Etafilcon A	Daily Wear	+6.00D to -9.00D +1.50/+2.50D	14.2	8.5
Lens D	Proclear® Multifocal – Distance design	Cooper Vision (USA)	Omafilcon A	Daily wear	+4.00D to -10.00D Low/High	14.4	8.5 to 8.7
Lens E	Proclear® Multifocal – Near design	Cooper Vision (USA)	Omafilcon A	Daily wear	+4.00D to -10.00D Low/High	14.4	8.5 to 8.7
Lens F	PureVision® multifocal	Bausch & Lomb (USA)	Balafilcon A	Daily wear	+6.00D to -10.00D Low/High	14.0	8.6
Lens G	CLARITI® 1 Day multifocal	Sauflon (UK)	Filcon II multifocal	Daily wear	+5.00D to -6.00 Low/High	14.1	8.6
Lens H	Prototype 1	Lathe Manufactured	Hioxifilcon A/B/D	Daily wear	+4.00D to -10.00D	13.5 to 14.5	8.1 to 8.7
Lens I	Prototype 2	Lathe Manufactured	Hioxifilcon A/B/D	Daily wear	+4.00D to -10.00D	13.5 to14.5	8.1 to 8.7
Lens J	Prototype 3	Lathe Manufactured	Hioxifilcon A/B/D	Daily wear	+4.00D to -10.00D	13.5 to14.5	8.1 to 8.7
Lens K	Prototype 4	Lathe Manufactured	Hioxifilcon A/B/D	Daily wear	+4.00D to -10.00D	13.5 to14.5	8.1 to 8.7

Table 19 List of the lenses used in the clinical study

Subjective response questionnaire:

1. Quality of distance, intermediate and near vision on a visual analogue scale of 1 to 10.
2. Rating of distance and near ghosting on a ghosting analogue scale of 1 to 10.
3. Overall rating of vision performance on a visual analogue scale of 1 to 10.

Figures 82 to 108 show the subjective and objective results obtained from the clinical study. The distance, intermediate, near and over all vision ratings were measured on a visual analogue scale ranging from 1 to 10 in steps of 1, where 1 represented blurred and/or hazy vision and 10 represented clear and/or sharp vision. The ghosting vision rating at distance and near were measured on a ghosting visual analogue scale ranging from 1 to 10 in steps of 1, where 1 represented no ghosting and/or doubling and 10 represented extreme ghosting and/or doubling. The lack of ghosting was calculated by subtracting ghosting score from 11 points. Cumulative vision results were obtained by averaging the distance, intermediate and near vision results. Cumulative ghosting results were obtained by averaging the ghosting at distance and near distances.

Other exemplary embodiments are described in the following sets of examples A to K:

Example set A:

(A1) A lens for an eye, the lens having an optical axis and an aberration profile about its optical axis, the aberration profile: having a focal distance; and including higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), herein the aberration profile provides, for a model eye with no aberrations, or substantially no, aberrations, and an on-axis length equal to, or substantial equal to, the focal distance: a retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth; and a RIQ of at least 0.3 wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(A2) A lens for an eye, the lens having an optical axis and an aberration profile about its optical axis, the aberration profile: having a focal distance; and including higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary

spherical aberration component C(6,0), herein the aberration profile provides, for a model eye with no aberrations and an on-axis length equal to the focal distance: a retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth; and a RIQ of at least 0.3 wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(A3) A lens for an eye, the lens having an optical axis, a focal distance and being characterised by: an aberration profile about the lens's optical axis, the aberration profile: including higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), herein the aberration profile provides, for a model eye with no aberrations, or substantially no, aberrations, and an on-axis length equal to, or substantial equal to, the focal distance: a retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth; and a RIQ of at least 0.3, wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(A4) A lens for an eye, the lens having at least one optical axis and at least one optical profile substantially about the at least one optical axis, the optical profile: having at least one focal distance; and including one or more higher order aberrations, wherein the profile provides, for a model eye with substantially no aberrations an on-axis length equal to, or substantially equal to, the desired focal distance; a retinal image quality (RIQ) with a through focus slope that improves in a direction of eye growth; and a RIQ of at least 0.3; wherein the RIQ is measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(A5) A lens for an eye, the lens having an optical axis and an aberration profile about its optical axis, the aberration profile: having a focal distance; and including higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), herein the aberration profile provides, for a model eye with no aberrations, or substantially no, aberrations, and an on-axis length equal to, or

substantial equal to, the focal distance: a retinal image quality (RIQ) with a through focus slope that improves in a direction of eye growth; and a RIQ of at least 0.3, wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(A6) A lens for an eye, the lens having an optical axis and an aberration profile about its optical axis, the aberration profile: having a focal distance; and including higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), herein the aberration profile provides, for a model eye with no aberrations and an on-axis length equal to the focal distance: a retinal image quality (RIQ) with a through focus slope that improves in a direction of eye growth; and a RIQ of at least 0.3, wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(A7) A lens for an eye, the lens having an optical axis, a focal distance and being characterised by: an aberration profile about the lens's optical axis, the aberration profile: including higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), herein the aberration profile provides, for a model eye with no aberrations, or substantially no, aberrations, and an on-axis length equal to, or substantial equal to, the focal distance: a retinal image quality (RIQ) with a through focus slope that improves in a direction of eye growth; and a RIQ of at least 0.3, wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(A8) A lens for an eye, the lens having at least one optical axis and at least one optical profile substantially about the at least one optical axis, the optical profile: having at least one focal distance; and including one or more higher order aberrations, wherein the profile provides, for a model eye with substantially no aberrations an on-axis length equal to, or substantially equal to, the desired focal distance; a retinal image quality (RIQ) with a through focus slope that improves in a direction of eye growth; and a RIQ of at least 0.3;

wherein the RIQ is measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(A9) The lens of one or more A examples, wherein the focal distance is a prescription focal distance for a myopic eye and wherein the focal distance differs from the focal distance for a C(2,0) Zernike coefficient of the aberration profile.

(A10) The lens of one or more A examples, wherein the focal distance is a prescription focal distance for a hyperopic eye and wherein the focal distance differs from the focal distance for a C(2,0) Zernike coefficient of the aberration profile.

(A11) The lens of one or more A examples, wherein the higher order aberrations include at least two spherical aberration terms selected from the group C(4,0) to C(20,0).

(A12) The lens of one or more A examples, wherein the higher order aberrations include at least three spherical aberration terms selected from the group C(4,0) to C(20,0).

(A13) The lens of one or more A examples, wherein the higher order aberrations include at least four spherical aberration terms selected from the group C(4,0) to C(20,0).

(A14) The lens of one or more A examples, wherein the higher order aberrations include at least five spherical aberration terms selected from the group C(4,0) to C(20,0).

(A15) The lens of one or more A examples, wherein the higher order aberrations include at least six spherical aberration terms selected from the group C(4,0) to C(20,0).

(A16) The lens of one or more A examples, wherein the higher order aberrations include at least seven spherical aberration terms selected from the group C(4,0) to C(20,0).

(A17) The lens of one or more A examples, wherein the magnitude of higher order aberrations included is at least 0.01 um over a 4 mm, 5 mm or 6 mm pupil diameter

(A18) The lens of one or more A examples, wherein the magnitude of higher order aberrations included is at least 0.02 um over a 4 mm, 5 mm or 6 mm pupil diameter

(A19) The lens of one or more A examples, wherein the magnitude of higher order aberrations included is at least 0.03 um over a 4 mm, 5 mm or 6 mm pupil diameter

(A20) The lens of one or more A examples, wherein the magnitude of higher order aberrations included is at least 0.04 um over a 4 mm, 5 mm or 6 mm pupil diameter

(A21) The lens of one or more A examples, wherein the magnitude of higher order aberrations included is at least 0.05 um over a 4 mm, 5 mm or 6 mm pupil diameter

(A22) The lens of one or more A examples, wherein the average slope over a horizontal field of

at least -20° to +20° degrades in a direction of eye growth.

(A23) The lens of one or more A examples, wherein the average slope over a vertical field of at least -20° to +20° degrades in the direction of eye growth.

(A24) The lens of one or more A examples, wherein the slope for a substantial portion of the field angles over a horizontal field of at least -20° to +20° degrades in the direction of eye growth.

(A25) The lens of one or more A examples, wherein the slope for a substantial portion of the field angles over a vertical field of at least -20° to +20° degrades in the direction of eye growth.

(A26) The lens of one or more A examples, wherein the aberration profile provides a RIQ of at least 0.3 at the focal length for a substantial portion of the pupil diameters in the range 3 mm to 6 mm.

(A27) The lens of one or more A examples, wherein the aberration profile provides a RIQ of at least 0.3 at the focal length for a substantial portion of pupil diameters in the range 4 mm to 5 mm.

(A28) The lens of one or more A examples, wherein the aberration profile provides a RIQ with a through focus slope that degrades in the direction of eye growth when primary astigmatism is added to the aberration profile.

(A29) The lens of one or more A examples, wherein the aberration profile provides a RIQ with a through focus slope that improves in the direction of eye growth when primary astigmatism is added to the aberration profile.

(A30) The lens of one or more A examples, wherein the aberration profile provides a RIQ with a through focus slope that degrades in the direction of eye growth when secondary astigmatism is added to the aberration profile.

(A31) The lens of one or more A examples, wherein the aberration profile provides a RIQ with a through focus slope that improves in the direction of eye growth when secondary astigmatism is added to the aberration profile.

(A32) The lens of one or more A examples, wherein the RIQ is, or is characterised by:

$$RIQ = \frac{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}|^2))))}{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}|^2))))}$$

$$RIQ = \frac{\iint_{-Fmin}^{+Fmax} CSF(x,y) * \left(\left(\left(\mathfrak{I}FT\left(\left|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}\right|^2\right)\right)\right)\right)}{\iint_{-Fmin}^{+Fmax} CSF(x,y) * \left(\left(\left(\mathfrak{I}FT\left(\left|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}\right|^2\right)\right)\right)\right)},$$

wherein:

Fmin is 0 cycles/degree and *Fmax* is 30 cycles/degree;

CSF(x, y) denotes the contrast sensitivity function,

CSF(F)=2.6(0.0192+0.114f)$e^{-(0.114f)^{1.1}}$,

where *f* specifies the tested spatial frequency, in the range of F_{min} to F_{max};

FT denotes a 2D fast Fourier transform;

A(ρ,θ) denotes the pupil diameter;

W(ρ,θ) denotes wavefront phase of the test case measured for i=1 to 20;

$$W(\rho,\theta) = \sum_{i=1}^{k} a_i Z_i(\rho,\theta)$$

Wdiff(ρ, θ) denotes wavefront phase of the diffraction limited case;

ρ and *θ* are normalised polar coordinates, where ρ represents the radial coordinate and θ represents the angular coordinate or azimuth; and

λ denotes wavelength.

(A33) A lens including an optical axis and an aberration profile about the optical axis that provides: a focal distance for a C(2,0) Zernike coefficient term; a peak Visual Strehl Ratio ('first Visual Strehl Ratio') within a through focus range, and a Visual Strehl Ratio that remains at or above a second Visual Strehl Ratio over the through focus range that includes said focal distance, wherein the Visual Strehl Ratio is measured for a model eye with no, or substantially no, aberration and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a wavelength selected from within the range 540 nm to 590 nm inclusive, and wherein the first Visual Strehl Ratio is at least 0.35, the second Visual Strehl Ratio is at least 0.1 and the through focus range is at least 1.8 Dioptres.

(A34) The lens of one or more A examples, wherein the first Visual Strehl Ratio is at least 0.4.

(A35) The lens of one or more A examples, wherein the first Visual Strehl Ratio is at least 0.5.

(A36) The lens of one or more A examples, wherein the first Visual Strehl Ratio is at least 0.6.

(A37) The lens of one or more A examples, wherein the first Visual Strehl Ratio is at least 0.7.

(A38) The lens of one or more A examples, wherein the first Visual Strehl Ratio is at least 0.8.

(A39) The lens of one or more A examples, wherein the second Visual Strehl Ratio is at least 0.1, 0.12, 0.14, 0.16, 0.18 or 0.2.

(A40) The lens of one or more A examples, wherein the through focus range is at least 1.8 Dioptres.

(A41) The lens of one or more A examples, wherein the through focus range is at least 1.9 Dioptres.

(A42) The lens of one or more A examples, wherein the through focus range is at least 2 Dioptres.

(A43) The lens of one or more A examples, wherein the through focus range is at least 2.1 Dioptres.

(A44) The lens of one or more A examples, wherein the through focus range is at least 2.25 Dioptres.

(A45) The lens of one or more A examples, wherein the through focus range is at least 2.5 Dioptres.

(A46) The lens of one or more A examples, wherein the lens has a prescription focal distance located within 0.75 Dioptres of an end of the through focus range.

(A47) The lens of one or more A examples, wherein the lens has a prescription focal distance located within 0.5 Dioptres of an end of the through focus range.

(A48) The lens of one or more A examples, wherein the lens has a prescription focal distance located within 0.3 Dioptres of an end of the through focus range.

(A49) The lens of one or more A examples, wherein the lens has a prescription focal distance located within 0.25 Dioptres of an end of the through focus range.

(A50) The lens of one or more A examples, wherein the end of the through focus range is the negative power end.

(A51) The lens of one or more A examples, wherein the end of the through focus range is the positive power end.

(A52) The lens of one or more A examples, wherein the Visual Strehl Ratio remains at or above the second Visual Strehl Ratio over the through focus range and over a range of pupil diameters of at least 1 mm.

(A53) The lens of one or more A examples, wherein the Visual Strehl Ratio remains at or above the second Visual Strehl Ratio over the through focus range and over a range of pupil diameters of at least 1.5 mm.

(A54) The lens of one or more A examples, wherein the Visual Strehl Ratio remains at or above the second Visual Strehl Ratio over the through focus range and over a range of pupil diameters of at least 2 mm.

(A55) The lens of one or more A examples, wherein the combination of higher order aberrations includes at least one of primary spherical aberration and secondary spherical aberration.

(A56) The lens of one or more A examples, wherein the higher order aberrations include at least two spherical aberration terms selected from the group C(4,0) to C(20,0).

(A57) The lens of one or more A examples, wherein the higher order aberrations include at least three spherical aberration terms selected from the group C(4,0) to C(20,0).

(A58) The lens of one or more A examples, wherein the higher order aberrations include at least five spherical aberration terms selected from the group C(4,0) to C(20,0).

(A59) The lens of one or more A examples, wherein the aberration profile is substantially described using only spherical aberration Zernike coefficients C(4,0) to C(20,0).

(A60) The lens of one or more A examples, wherein the RIQ for every field angle over a horizontal field of at least -10° to +10° is at least 0.3, 0.35 or 0.4.

(A61) The lens of one or more A examples, wherein the RIQ for every field angle over a horizontal field of at least -20° to +20° is at least 0.3, 0.35 or 0.4.

(A62) The lens of one or more A examples, wherein the RIQ for every field angle over a horizontal field of at least -30° to +30° is at least 0.3, 0.35 or 0.4.

(A63) The lens of one or more A examples, wherein the lens does not substantially reduce the amount of light passing through the lens.

(A64) A method for a presbyopic eye, the method comprising identifying at least one wavefront aberration profile for the eye, the at least one wavefront aberration profile including at least two spherical aberration terms, wherein the prescription focal distance of the lens is determined taking into account said at least one spherical aberration and wherein the prescription focal distance of the lens is at least +0.25D relative to a focal distance for a C(2,0) Zernike coefficient term of the at least one wavefront aberration and producing one or more of the following: a device, lens and corneal profile for the eye to affect said at least one wavefront aberration profile.

(A65) A method for a myopic or emmetropic eye, the method comprising forming an aberration

for the eye and applying or prescribing the aberration profile, the aberration profile: having a focal distance; and including at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), wherein the aberration profile provides, for the eye: a retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth; and a RIQ of at least 0.3; wherein said RIQ is Visual Strehl Ratio measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(A66) A method for a hyperopic eye, the method comprising forming an aberration for the eye and applying or prescribing the aberration profile, the aberration profile: having a focal distance; and including at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), wherein the aberration profile provides, for the eye: a retinal image quality (RIQ) with a through focus slope that improves in a direction of eye growth; and a RIQ of at least 0.3; wherein said RIQ is Visual Strehl Ratio measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(A67) The method of one or more A examples, wherein applying or prescribing the aberration profile comprises providing a lens, the lens having an aberration profile including at least two spherical aberration terms selected from the group C(4,0) to C(20,0).

(A68) The method of one or more A examples, wherein applying or prescribing the aberration profile comprises providing a lens, the lens having an aberration profile including at least three spherical aberration terms selected from the group C(4,0) to C(20,0).

(A69) The method of one or more A examples, wherein applying or prescribing the aberration profile comprises providing a lens, the lens having an aberration profile including at least five spherical aberration terms selected from the group C(4,0) to C(20,0).

(A70) A method for a myopic eye, the method comprising identifying a wavefront aberration profile for the eye and applying or prescribing the aberration profile, the wavefront aberration profile including at least two spherical aberration terms, wherein the prescription focal distance of the lens is determined taking into account said spherical aberration and wherein the prescription focal distance is at least +0.1D relative to a focal distance for a C(2,0) Zernike coefficient term of the wavefront aberration profile and wherein the wavefront aberration profile provides a degrading retinal image quality in the

direction posterior to the retina.

(A71) A method for a hyperopic eye, the method comprising identifying a wavefront aberration profile for the eye and applying or prescribing the aberration profile, the wavefront aberration profile including at least two spherical aberration terms, wherein the prescription focal distance of the lens is determined taking into account said spherical aberration and wherein the prescription focal distance is at least +0.1D relative to a focal distance for a C(2,0) Zernike coefficient term of the wavefront aberration profile and wherein the wavefront aberration profile provides a improving retinal image quality in the direction posterior to the retina.

(A72) The method of one or more A examples, wherein the prescription focal distance is at least +0.1D relative to a focal distance for a C(2,0) Zernike coefficient term of the wavefront aberration profile.

(A73) A method for a hyperopic eye, the method comprising identifying a wavefront aberration profile for the eye and applying or prescribing the aberration profile, the wavefront aberration profile including at least two spherical aberration terms, wherein the prescription focal distance of the lens is determined taking into account said spherical aberration and wherein at the prescription focal distance the wavefront aberration profile provides an improving retinal image quality in the direction posterior to the retina.

(A74) The method of one or more A examples, wherein the lens does not substantially reduce the amount of light passing through the lens.

Example set B:

(B1) A multifocal lens comprising: an optical axis; an effective near additional power of at least 1D; the optical properties of the multifocal lens are configured with an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus term and at least two spherical aberration term; and the multifocal lens is configured to provide a visual performance over intermediate and far distances that is at least substantially equivalent to the visual performance of a correctly prescribed single-vision lens at the far visual distance; and is configured to provide minimal ghosting at far, intermediate and near distances.

(B2) The multifocal lens of one or more B claims, wherein the lens is configured to provide near visual acuity of at least 6/6 in individuals that can achieve 6/6 visual acuity.

(B3) The multifocal lens of one or more B claims, wherein the lens is configured to provide at least acceptable visual performance at near distances.

(B4) A multifocal lens comprising: an optical axis; an effective near additional power of at least 0.75D; the optical properties of the multifocal lens are configured or described based at least in part on an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus term and at least two spherical aberration terms; and the multifocal lens is configured to provide a visual performance, along a range of substantially continuous near visual distances, wherein the visual performance of the multifocal lens is at least substantially equivalent to the visual performance of a correctly prescribed single-vision lens at the far visual distance, the multifocal lens is configured to provide a visual performance, along a range of substantially continuous intermediate and far visual distances, wherein the visual performance of the multifocal lens is at least substantially equivalent to the visual performance of a correctly prescribed single-vision lens at the far visual distance.

(B5) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens are configured or described based at least in part on an aberration profile associated with the optical axis; wherein the aberration profile is comprised of a defocus term and at least two spherical aberration terms; and wherein the multifocal lens is configured to provide a visual performance, along a range of substantially continuous visual distances, including near, intermediate and far distances, wherein the visual performance of the multifocal lens is at least substantially equivalent to the visual performance of a correctly prescribed single-vision lens at the far visual distance.

(B6) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens are configured or described based at least in part on an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus term and at least two spherical aberration terms; and the multifocal lens is configured to provide a visual performance, along substantially continuous visual distances, including substantially near distances, substantially intermediate distances, and substantially far distances, wherein the visual performance of the multifocal lens is at least substantially equivalent to the visual performance of an appropriately prescribed single-vision lens at the far visual distance.

(B7) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens are configured or described based on an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus term and at least two aberration terms; and

the multifocal lens is configured to provide a visual performance, along a range of visual distances, including near, intermediate and far distances, wherein the visual performance of the lens is at least equivalent to the visual performance of a single-vision lens at the far visual distance.

(B8) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens are configured or described based on an aberration profile associated with the optical axis; wherein the aberration profile is comprised of a defocus term and at least two aberration terms; and wherein the multifocal lens is configured to provide a visual performance, along a range of visual distances, including near, intermediate and far distances, wherein the visual performance of the lens is at least equivalent to the visual performance of a single-vision lens at the far visual distance.

(B9) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens are configured or described based at least in part on an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus term, at least two spherical aberration term and at least one asymmetric term; and the multifocal lens is configured to provide a visual performance, along a range of substantially continuous visual distances, including near, intermediate and far distances, wherein the visual performance of the multifocal lens is at least substantially equivalent to the visual performance of a correctly prescribed single-vision lens at the far visual distance.

(B10) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens are configured or described based on an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus term and at least two spherical aberration terms; and the multifocal lens is configured to provide a visual performance over intermediate and far distances that is at least substantially equivalent to the visual performance of a correctly prescribed single-vision lens at the far visual distance; and is configured to provide minimal ghosting at far, intermediate and near distances

(B11) A multifocal lens for correction of presbyopia comprising: an optical axis; the optical properties of the multifocal lens are configured or described based on an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus terms, at least two spherical aberration terms and at least one asymmetric aberration term; and the multifocal lens is configured to provide a visual performance over intermediate and far distances that is at least substantially equivalent to the visual performance of a correctly

prescribed single-vision lens at the far visual distance; and is configured to provide minimal ghosting at far, intermediate and near distances

(B12) A multifocal lens for correction of presbyopia comprising: an optical axis; combinations of one more areas of different focal powers; and the optical properties of the multifocal lens is configured to provide a visual performance for a presbyopic eye over intermediate and far distances that is at least substantially equivalent to the visual performance of a correctly prescribed single-vision lens at the far visual distance; and is configured to provide minimal ghosting at far, intermediate and near distances

(B13) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens is characterised at least in part on an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus term and at least two spherical aberration term; and the multifocal lens is configured to provide a visual performance over intermediate and far distances that is at least substantially equivalent to the visual performance of a correctly prescribed single-vision lens at the far visual distance; and is configured to provide minimal ghosting at far, intermediate and near distances

(B14) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens are configured or described based at least in part on an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus term and at least two spherical aberration terms; and the multifocal lens is configured to provide a visual performance over intermediate and far distances that is at least substantially equivalent to the visual performance of a prescribed single-vision lens at the far visual distance; and is configured to provide minimal ghosting at far, intermediate and near distances.

(B15) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens are configured based on an aberration profile associated with the optical axis of the lens; the aberration profile is comprised of a defocus term and at least two spherical aberration terms; and the multifocal lens is configured to provide a visual performance over intermediate and far distances that is at least substantially equivalent to the visual performance of a correctly prescribed single-vision lens at the far visual distance; and is configured to provide minimal ghosting at far, intermediate and near distances.

(B16) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens being characterised based on an aberration profile associated with the optical axis of the lens; the aberration profile is comprised of a defocus term and at least two spherical aberration terms; and the multifocal lens is configured to provide a visual performance

over intermediate and far distances that is at least substantially equivalent to the visual performance of a effectively prescribed single-vision lens at the far visual distance; and is configured to provide minimal ghosting at far, intermediate and near distances.

(B17) The multifocal lens of one or more B examples, wherein the lens does not substantially reduce the amount of light passing through the lens.

(B18) The multifocal lens of one or more B examples, wherein the amount of light passing through the lens is at least 80%, 85%, 90%, 95% or 99%.

(B19) The multifocal lens of one or more B examples, wherein the single-vision lens is one or more of the following: prescribed, appropriately prescribed, correctly prescribed and effectively prescribed.

(B20) The multifocal lens of one or more B examples, wherein the single-vision lens is a lens with a substantially constant power across a substantial portion of an optic zone of the single-vision lens.

(B21) The multifocal lens of one or more B examples, wherein the single-vision lens is a lens with a constant power across a portion of an optic zone of the single-vision lens.

(B22) The multifocal lens of one or more B examples, wherein the single-vision lens is a lens with a substantially constant power across a portion of one or more optic zones of the single-vision lens.

(B23) The multifocal lens of one or more B examples, wherein the multifocal lens is used for a presbyopic eye.

(B24) The multifocal lens of one or more B examples, wherein the lens is configured for a presbyopic eye.

(B25) The multifocal lens of one or more B examples, wherein the lens is configured to optically correct or substantially correct presbyopia.

(B26) The multifocal lens of one or more B examples, wherein the lens is configured to mitigate or substantially mitigate the optical consequences of presbyopia.

(B27) The multifocal lens of one or more B examples, wherein the lens is configured to alter or substantially alter a presbyopic condition to a non-presbyopic condition.

(B28) The multifocal lens of one or more B examples, wherein the multifocal lens is used for at least correcting a presbyopic eye condition and when used provides an appropriate correction to adjust the vision of the user towards substantially normal non-presbyopic vision.

(B29) The multifocal lens of one or more B examples, wherein normal vision is 6/6 or better.

(B30) The multifocal lens of one or more B examples, wherein the multifocal lens is further characterised by minimal, substantially no or no, ghosting at near, intermediate and far distances.

(B31) The multifocal lens of one or more B examples, wherein the multifocal lens is further characterised by minimal, substantially no or no, ghosting at near distances, intermediate distances and far distances.

(B32) The multifocal lens of one or more B examples, wherein the multifocal lens is further configured to provide minimal, substantially no or no, ghosting at near, intermediate and far distances.

(B33) The multifocal lens of one or more B examples, wherein the minimal ghosting is a lack of an undesired secondary image appearing at the image plane of the optical system.

(B34) The multifocal lens of one or more B examples, wherein the minimal ghosting is a lack of an undesired secondary image appearing on the retina of the eye.

(B35) The multifocal lens of one or more B examples, wherein the minimal ghosting is a lack of an undesired double image appearing on the retina of the eye.

(B36) The multifocal lens of one or more B examples, wherein the minimal ghosting is a lack of false out-of-focus image appearing along side of the primary image in an optical system.

(B37) The multifocal lens of one or more B examples, wherein the multifocal lens is further configured to provide a sufficient lack of ghosting in a portion of near, intermediate and far distances.

(B38) The multifocal lens of one or more B examples, wherein the multifocal lens is further configured to provide a sufficient lack of ghosting at near distances, intermediate distances and far distances.

(B39) The multifocal lens of one or more B examples, wherein the multifocal lens is further configured to provide a sufficient lack of ghosting in a portion of two or more of the following: near, intermediate and far distances.

(B40) The multifocal lens of one or more B examples, wherein lack of ghosting is lack of undesired image appearing at the image plane of the optical system.

(B41) The multifocal lens of one or more B examples, wherein lack of ghosting is a lack of false out of focus images appearing along side of the primary image in an optical system.

(B42) The multifocal lens of one or more B examples, wherein the multifocal lens is further configured to provide a sufficient lack of ghosting in a portion of two or more of the following: near distances, intermediate distances and far distances.

(B43) The multifocal lens of one or more B examples, wherein the multifocal lens is further configured to provide the RIQ of at least 0.1, 0.13, 0.17, 0.2, 0.225, or 0.25 in the near distance range, the RIQ of at least 0.27, 0.3, 0.33, 0.35, 0.37 or 0.4 in the intermediate distance range and the RIQ of at least 0.35, 0.37, 0.4, 0.42, 0.45, 0.47, or 0.5 in the far distance range.

(B44) The multifocal lens of one or more B examples, wherein the multifocal lens is further configured to provide two or more of the following: the RIQ of at least 0.1, 0.13, 0.17, 0.2, 0.225, or 0.25 in the near distance range, the RIQ of at least 0.27, 0.3, 0.33, 0.35, 0.37 or 0.4 in the intermediate distance range and the RIQ of at least 0.35, 0.37, 0.4, 0.42, 0.45, 0.47, or 0.5 in the far distance range.

(B45) The multifocal lens of one or more B examples, wherein the RIQs are selected in the near, intermediate and far distance ranges such that the multifocal lens is configured to provide minimal, or no, ghosting in near, intermediate and far distances.

(B46) The multifocal lens of one or more B examples, wherein the multifocal lens is configured to substantially eliminate, or substantially reduce, ghosting at near, intermediate and far distances.

(B47) The multifocal lens of one or more B examples, wherein the multifocal lens is configured to substantially eliminate, or substantially reduce, ghosting at near distances, intermediate distances and far distances.

(B48) The multifocal lens of one or more B examples, wherein near distance is the range of 33 cm to 50 cm or 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm, 50 cm to 80 cm or 50 cm to 70 cm; and far distance is the range of 100 cm or greater, 80 cm or greater or 70 cm or greater.

(B49) The multifocal lens of one or more B examples, wherein near distance is the range of 33 cm to 50 cm or 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm, 50 cm to 80 cm or 50 cm to 70 cm; and far distance is the range of 100 cm or greater, 80 cm or greater or 70 cm or greater and the near, intermediate and far distances are determined by the distance from the object being focused on.

(B50) The multifocal lens of one or more B examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm or greater.

(B51) The multifocal lens of one or more B examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the

range of 100 cm or greater and the near, intermediate and far distances are determined by the distance from the object being focused on.

(B52) The multifocal lens of one or more B examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm to optical infinity.

(B53) The multifocal lens of one or more B examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm to optical infinity and the near, intermediate and far distances are determined by the distance from the object being focused on.

(B54) The multifocal lens of one or more B examples, wherein the multifocal lens is configured to minimise, or reduce, ghosting at near, intermediate and far distances when used on an eye.

(B55) The multifocal lens of one or more B examples, wherein the multifocal lens is configured to minimise, or reduce, ghosting at near distances, intermediate distances and far distances when used on an eye.

(B56) The multifocal lens of one or more B examples, wherein the range of substantially continuous distances is continuous.

(B57) The multifocal lens of one or more B examples, wherein the range of substantially continuous distances is continuous and goes from 40 cm to optical infinity.

(B58) The multifocal lens of one or more B examples, wherein the range of substantially continuous distances is from 33 cm to optical infinity.

(B59) The multifocal lens of one or more B examples, wherein the lens is configured such that at least 40%, 50%, 60% or 70% of a randomly selected group of 15 affected individuals in the near distances, intermediate distances and far distances perceive minimal, or no, ghosting at near distances, intermediate distances and far distances.

(B60) The multifocal lens of one or more B examples, wherein the lens is configured such that at least 60%, 70%, 80% or 90% of a randomly selected group of 15 affected individuals in the intermediate distances and far distances perceive minimal, or no, ghosting at intermediate distances and far distances.

(B61) The multifocal lens of one or more B examples, wherein the single vision lens provides a visual acuity for the user of one or more of the following: at least 20/20, at least 20/30, at least 20/40, at least about 20/20, at least about 20/30 and at least about 20/40, at far visual distances.

(B62) The multifocal lens of one or more B examples, wherein the aberration profile is comprised of a defocus term and at least two, two or more, three, three or more, four, four or more, five, five or more, six, six or more, seven, seven or more, eight, eight or more, nine, nine or more, ten, or ten or more spherical aberration terms.

(B63) The multifocal lens of one or more B examples, wherein the aberration profile is comprised of a defocus term and at least two, three, four, five, six, seven, eight, nine, or at least ten spherical aberration terms.

(B64) The multifocal lens of one or more B examples, wherein the aberration profile is comprised of a defocus term and spherical aberration terms between C(4,0) and C(6,0), C(4,0) and C(8,0), C(4,0) and C(10,0), C(4,0) and C(12,0), C(4,0) and C(14,0), C(4,0) and C(16,0), C(4,0) and C(18,0), or C(4,0) and C(20,0).

(B65) The multifocal lens of one or more B examples, wherein the single vision lens provides a visual acuity that is the best-corrected visual acuity.

(B66) The multifocal lens of one or more B examples, wherein the best-corrected visual acuity is a visual acuity that cannot be substantially improved by further manipulating the power of the single vision lens.

(B67) The multifocal lens of one or more B examples, wherein the lens has two optical surfaces.

(B68) The multifocal lens of one or more B examples, wherein the least one aberration profile is along the optical axis of the lens.

(B69) The multifocal lens of one or more B examples, wherein the lens has a focal distance.

(B70) The multifocal lens of one or more B examples, wherein the aberration profile includes higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0).

(B71) The multifocal lens of one or more B examples, wherein the aberration profile provides, for a model eye with no, or substantially no, aberrations and an on-axis length equal to the focal distance: the retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth; and the RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(B72) The multifocal lens of one or more B examples, wherein the aberration profile provides, for a model eye with no, or substantially no, aberrations and an on-axis length equal to the focal distance: the retinal image quality (RIQ) with a through focus slope that improves in

a direction of eye growth; and the RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(B73) The multifocal lens of one or more B examples, wherein the lens has an optical axis and an aberration profile about its optical axis, the aberration profile: having a focal distance; and including higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), wherein the aberration profile provides, for a model eye with no, or substantially no, aberrations and an on-axis length equal, or substantially equal, to the focal distance: the RIQ with a through focus slope that degrades in a direction of eye growth; and the RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(B74) The multifocal lens of one or more B examples, wherein the lens has an optical axis and an aberration profile about its optical axis, the aberration profile: having a focal distance; and including higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), wherein the aberration profile provides, for a model eye with no, or substantially no, aberrations and an on-axis length equal, or substantially equal, to the focal distance: the RIQ with a through focus slope that improves in a direction of eye growth; and the RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(B75) The multifocal lens of one or more B examples, wherein the focal distance is a prescription focal distance for a myopic, hyperopic, astigmatic, and/or presbyopic eye and wherein the focal distance differs from the focal distance for a C(2,0) Zernike coefficient of the aberration profile.

(B76) The multifocal lens of one or more B examples, wherein the higher order aberrations include at least two spherical aberration terms selected from the group C(4,0) to C(20,0).

(B77) The multifocal lens of one or more B examples, wherein the higher order aberrations include at least three spherical aberration terms selected from the group C(4,0) to C(20,0).

(B78) The multifocal lens of one or more B examples, wherein the higher order aberrations include at least five spherical aberration terms selected from the group C(4,0) to C(20,0).

(B79) The multifocal lens of one or more B examples, wherein the average slope over a horizontal field of at least -20° to +20° degrades in a direction of eye growth.

(B80) The multifocal lens of one or more B examples, wherein the average slope over a horizontal field of at least -20° to +20° improves in a direction of eye growth.

(B81) The multifocal lens of one or more B examples, wherein the average slope over a vertical field of at least -20° to +20° degrades in a direction of eye growth.

(B82) The multifocal lens of one or more B examples, wherein the average slope over a vertical field of at least -20° to +20° improves in a direction of eye growth.

(B83) The multifocal lens of one or more B examples, wherein the slope for a substantial portion of the field angles over a horizontal field of at least -20° to +20° degrades in a direction of eye growth.

(B84) The multifocal lens of one or more B examples, wherein the substantial portion of the field angles over a horizontal field is at least 75%, 85%, 95% or 99% of the field angles.

(B85) The multifocal lens of one or more B examples, wherein the substantial portion of the field angles over a horizontal field is every field angle.

(B86) The multifocal lens of one or more B examples, wherein the slope for a substantial portion of the field angles over a vertical field of at least -20° to +20° degrades in a direction of eye growth.

(B87) The multifocal lens of one or more B examples, wherein the substantial portion of the field angles over a vertical field is every angle.

(B88) The multifocal lens of one or more B examples, wherein the substantial portion of the field angles over a vertical field is at least 75%, 85%, 95% or 99% of the field angles.

(B89) The multifocal lens of one or more B examples, wherein the aberration profile provides the RIQ of at least 0.3 at the focal length for a substantial portion of pupil diameters in the range 3 mm to 6 mm.

(B90) The multifocal lens of one or more B examples, wherein the aberration profile provides the RIQ of at least 0.3 at the focal length for a substantial portion of pupil diameters in the range 4 mm to 5 mm.

(B91) The multifocal lens of one or more B examples, wherein the aberration profile provides the RIQ with a through focus slope that degrades in a direction of eye growth when primary or secondary astigmatism is added to the aberration profile.

(B92) The multifocal lens of one or more B examples, wherein the aberration profile provides the RIQ with a through focus slope that improves in a direction of eye growth when primary or secondary astigmatism is added to the aberration profile.

(B93) The multifocal lens of one or more B examples, wherein the primary or secondary astigmatism is added to the desired aberration profile by altering one or more of the following terms: C(2,-2), C(2,2), C(4,-2), C(4,2), C(6,-2), and/or C(6,2).

(B94) The multifocal lens of one or more B examples, wherein the aberration profile provides the RIQ with a through focus slope that degrades in a direction of eye growth when secondary astigmatism is added to the aberration profile.

(B95) The multifocal lens of one or more B examples, wherein the secondary astigmatism is added to the desired aberration profile by altering one or more of the following terms: C(2,-2), C(2,2), C(4,-2), C(4,2), C(6,-2), and/or C(6,2).

(B96) The multifocal lens of one or more B examples, wherein the RIQ is characterised by

$$RIQ = \frac{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}|^2))))}{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}|^2))))}$$

$$RIQ = \frac{\iint_{-Fmin}^{+Fmax} CSF(x,y) * \left(\left(\left(\left|FT\left(\left|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}\right|^2\right)\right)\right)\right)}{\iint_{-Fmin}^{+Fmax} CSF(x,y) * \left(\left(\left(\left|FT\left(\left|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}\right|^2\right)\right)\right)\right)},$$

wherein:

Fmin is 0 cycles/degree and *Fmax* is 30 cycles/degree;

CSF(x, y) denotes the contrast sensitivity function,

$CSF(F)=2.6(0.0192+0.114f)e^{-(0.114f)^{1.1}}$,

where *f* specifies the tested spatial frequency, in the range of F_{min} to F_{max};

FT denotes a 2D fast Fourier transform;

$A(\rho,\theta)$ denotes the pupil diameter;

$W(\rho,\theta)$ denotes wavefront phase of the test case measured for i=1 to 20

$$W(\rho,\theta) = \sum_{i=1}^{k} a_i Z_i(\rho,\theta);$$

Wdiff(ρ, θ) denotes wavefront phase of the diffraction limited case;

ρ and θ are normalised polar coordinates, where ρ represents the radial coordinate and θ represents the angular coordinate or azimuth; and

λ denotes wavelength.

(B97) The multifocal lens of one or more B examples, wherein the multifocal lens includes an optical axis and an aberration profile along the optical axis that provides: a focal distance for a C(2,0) Zernike coefficient term; a peak Visual Strehl Ratio ('first Visual Strehl Ratio') within a through focus range, and a Visual Strehl Ratio that remains at or above a second Visual Strehl Ratio over the through focus range that includes said focal distance, wherein the Visual Strehl Ratio is measured for a model eye with no, or substantially no, aberration and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a wavelength selected from within the range 540 nm to 590 nm inclusive, and wherein the first Visual Strehl Ratio is at least 0.35, the second Visual Strehl Ratio is at least 0.1 and the through focus range is at least 1.8 Dioptres.

(B98) The multifocal lens of one or more B examples, wherein the multifocal lens includes an optical axis and an aberration profile along the optical axis that provides: a focal distance for a C(2,0) Zernike coefficient term; a peak Visual Strehl Ratio ('first Visual Strehl Ratio') within a through focus range, and a Visual Strehl Ratio that remains at or above a second Visual Strehl Ratio over the through focus range that includes said focal distance, wherein the Visual Strehl Ratio is measured for a model eye with no aberration and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a wavelength selected from within the range 540 nm to 590 nm inclusive, and wherein the first Visual Strehl Ratio is at least 0.35, the second Visual Strehl Ratio is at least 0.1 and the through focus range is at least 1.8 Dioptres.

(B99) The multifocal lens of one or more B examples, wherein the first Visual Strehl Ratio is at least 0.3, 0.35, 0.4, 0.5, 0.6, 0.7 or 0.8.

(B100) The multifocal lens of one or more B examples, wherein the second Visual Strehl Ratio is at least 0.1, 0.12, 0.15, 0.18 or 0.2.

(B101) The multifocal lens of one or more B examples, wherein the through focus range is at least 1.7, 1.8, 1.9, 2, 2.1, 2.25 or 2.5 Dioptres.

(B102) The multifocal lens of one or more B examples, wherein the lens has a prescription focal distance located within 0.75, 0.5, 0.3, or 0.25 Dioptres, inclusive, of an end of the through focus range.

(B103) The multifocal lens of one or more B examples, wherein the end of the through focus range is the negative power end.

(B104) The multifocal lens of one or more B examples, wherein the end of the through focus range is the positive power end.

(B105) The multifocal lens of one or more B examples, wherein the Visual Strehl Ratio remains at or above the second Visual Strehl Ratio over the through focus range and over a range of pupil diameters of at least 1 mm, 1.5 mm, 2 mm, 2.5 mm, or 3 mm.

(B106) The multifocal lens of one or more B examples, wherein the combination of higher order aberrations includes at least one of primary spherical aberration and secondary spherical aberration.

(B107) The multifocal lens of one or more B examples, wherein the higher order aberrations include at least two, three, or five spherical aberration terms selected from the group C(4,0) to C(20,0).

(B108) The multifocal lens of one or more B examples, wherein the aberration profile is substantially charactered using only spherical aberration Zernike coefficients C(4,0) to C(20,0).

(B109) The multifocal lens of one or more B examples, wherein the RIQ for a substantial portion of the angles over a horizontal field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.4.

(B110) The multifocal lens of one or more B examples, wherein the RIQ for a substantial portion of the angles over a horizontal field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.35.

(B111) The multifocal lens of one or more B examples, wherein the RIQ for a substantial portion of the angles over a horizontal field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.3.

(B112) The multifocal lens of one or more B examples, wherein the lens is one or more of the following: contact lens, corneal onlays, corneal inlays, anterior chamber intraocular lens or posterior chamber intraocular lens.

(B113) The multifocal lens of one or more B examples, wherein the lens is one of the following: contact lens, corneal onlays, corneal inlays, anterior chamber intraocular lens or posterior chamber intraocular lens.

(B114) The multifocal lens of one or more B examples, wherein a first multifocal lens is provided based on one or more of the B examples and a second multifocal lens is provided based on one or more of the B examples to form a pair of lenses.

(B115) The multifocal lens of one or more B examples, wherein the first multifocal lens is provided based on one or more of the B examples and a second lens is provided to form a pair of lenses.

(B116) The multifocal lens of one or more B examples, wherein a pair of multifocal lenses are provided for use by an individual to substantially correct the individual's vision.

(B117) A method for making or using one or more of the multifocal lenses of one or more B examples.

Example set C:

(C1) A lens comprising: an optical axis; at least two optical surfaces; wherein the lens is configured to provide a visual performance on a presbyopic eye substantially equivalent to the visual performance of a single-vision lens on the pre-presbyopic eye; and wherein the lens has an aperture size greater than 1.5 mm.

(C2) A lens comprising: an optical axis; at least two optical surfaces; wherein the lens is configured to provide a visual performance on a presbyopic eye substantially equivalent to the visual performance of a correctly prescribed single-vision lens on the pre-presbyopic eye; and wherein the lens has an aperture size greater than 1.5 mm.

(C3) A lens comprising: an optical axis; at least two optical surfaces; wherein the lens is configured to provide a visual performance for a presbyopic condition substantially equivalent to the visual performance of an appropriately prescribed single-vision lens for the pre-presbyopic condition; and wherein the lens has an aperture size greater than 1.5 mm.

(C4) A lens comprising: an optical axis; at least two optical surfaces; wherein the lens is configured to provide a visual performance on a presbyopic eye substantially equivalent to the visual performance of a effectively prescribed single-vision lens on the pre-presbyopic eye; and wherein the lens has an aperture size greater than 1.5 mm.

(C5) The lens of one or more of the C examples, wherein the lens is configured based on an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus term and at least two spherical aberration terms; and the lens is configured to provide the visual performance, along a range of substantially continuous visual distances, including near, intermediate and far distances.

(C6) The lens of one or more C examples, wherein the lens does not substantially reduce the amount of light passing through the lens.

(C7) The lens of one or more C examples, wherein the amount of light passing through the lens is at least 80%, 85%, 90%, 95% or 99%.

(C8) The lens of one or more of the C examples, wherein the lens is configured to provide the visual performance, along substantially continuous visual distances, including substantially near distances, substantially intermediate distances, and substantially far distances.

(C9) The lens of one or more of the C examples, wherein the lens is configured to provide the visual performance, along continuous visual distances, including near distances, intermediate distances, and far distances.

(C10) The lens of one or more of the C examples, wherein the lens is configured to provide the visual performance, along a range of visual distances, including near, intermediate and far distances.

(C11) The lens of one or more of the C examples, wherein the aberration profile is comprised of the defocus term, the at least two spherical aberration terms and at least one asymmetric higher order aberration term.

(C12) The lens of one or more of the C examples, wherein the lens is characterised in part by the aberration profile associated with the optical axis of the lens.

(C13) The lens of one or more C examples, wherein the single-vision lens is one of the following: prescribed, correctly prescribed, appropriately prescribed, properly prescribed or effectively prescribed.

(C14) The lens of one or more C examples, wherein the lens is one or more of the following: contact lens, corneal onlays, corneal inlays, intra-ocular contact lens, intraocular lens, anterior chamber intraocular lens and posterior chamber intraocular lens.

(C15) The lens of one or more C examples, wherein the lens is one of the following: contact lens, corneal onlays, corneal inlays, intra-ocular contact lens, intraocular lens, anterior chamber intraocular lens or posterior chamber intraocular lens.

(C16) The lens of one or more C examples, wherein the single-vision lens is a lens with a substantially constant power across a substantial portion of an optic zone of the single-vision lens.

(C17) The lens of one or more C examples, wherein the single-vision lens is a lens with a constant power across a portion of an optic zone of the single-vision lens.

(C18) The lens of one or more C examples, wherein the single-vision lens is a lens with a substantially constant power across one or more portions of the optic zone of the single-vision lens.

(C19) The lens of one or more C examples, wherein the single-vision lens is a lens with a constant power across one or more portions of the optic zone of the single-vision lens.

(C20) The lens of one or more C examples, wherein the lens is configured to optically correct or mitigate presbyopia.

(C21) The lens of one or more C examples, wherein the lens is configured to alter, or substantially alter, a presbyopic condition to a non-presbyopic condition.

(C22) The lens of one or more C examples, wherein the lens is used for at least correcting a presbyopic eye condition and when used provides a best available fit to adjust the vision of the user towards substantial normal vision.

(C23) The lens of one or more C examples, wherein the lens is further characterised by minimal, or no, ghosting at near, intermediate and far distances.

(C24) The lens of one or more C examples, wherein the lens is further configured to provide minimal, or no, ghosting at near, intermediate and far distances.

(C25) The lens of one or more C examples, wherein the lens is further configured to provide a sufficient lack of ghosting in a substantial portion of near, intermediate and far distances.

(C26) The lens of one or more C examples, wherein the lens is further configured to provide a sufficient lack of ghosting in a substantial portion of two or more of the following: near, intermediate and far distances.

(C27) The lens of one or more C examples, wherein the lens is further configured to provide a sufficient lack of ghosting in two or more of the following: near, intermediate and far distances.

(C28) The lens of one or more C examples, wherein the lens is further configured to provide the RIQ of at least 0.1, 0.12, 0.14, 0.16, 0.18 or 0.2 in the near distance range, the RIQ of at least 0.3, 0.32, 0.34, 0.36, 0.38 or 0.4 in the intermediate distance range and the RIQ of at least 0.4, 0.45, 0.5, 0.6 or 0.7 in the far distance range.

(C29) The lens of one or more C examples, wherein the lens is further configured to provide two or more of the following: the RIQ of at least 0.1, 0.12, 0.14, 0.16, 0.18 or 0.2 in the near distance range, the RIQ of at least .3, 0.32, 0.34, 0.36, 0.38 or 0.4 in the intermediate distance range and the RIQ of at least 0.4, 0.45, 0.5, 0.6 or 0.7 in the far distance range.

(C30) The lens of one or more C examples, wherein RIQs are selected in the near, intermediate and far distance ranges such that the lens is configured to provide minimal, or no, ghosting in near, intermediate and far distances.

(C31) The lens of one or more C examples, wherein the lens is configured to substantially eliminate, or substantially reduce, ghosting at near, intermediate and far distances.

(C32) The lens of one or more C examples, wherein near distance is the range of 33 cm to 50 cm or 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm, 50 cm to 80 cm or 50 cm to 70 cm; and far distance is the range of 100 cm or greater, 80 cm or greater or 70 cm or greater.

(C33) The lens of one or more C examples, wherein near distance is the range of 33 cm to 50 cm or 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm, 50 cm to 80 cm or 50 cm to 70 cm; and far distance is the range of 100 cm or greater, 80 cm or greater or 70 cm or greater and the near, intermediate and far distances are determined by the distance from the object being focused on.

(C34) The lens of one or more C examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm or greater.

(C35) The lens of one or more C examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm or greater and the near, intermediate and far distances are determined by the distance from the object being focused on.

(C36) The lens of one or more C examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm to optical infinity.

(C37) The lens of one or more C examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm to optical infinity and the near, intermediate and far distances are determined by the distance from the object being focused on.

(C38) The lens of one or more C examples, wherein the lens is configured to minimize, or reduce, ghosting at near, intermediate and far distances when used on the pre-presbyopic eye.

(C39) The lens of one or more C examples, wherein ghosting is measured when the lens is used on the pre-presbyopic eye.

(C40) The lens of one or more C examples, wherein the range of substantially continuous distances is continuous.

(C41) The lens of one or more C examples, wherein the range of substantially continuous distances is continuous and goes from 40 cm to optical infinity.

(C42) The lens of one or more C examples, wherein the range of substantially continuous distances is from 33 cm to optical infinity.

(C43) The lens of one or more C examples, wherein the lens is configured such that at least 40%, 50%, 60% or 70% of a randomly selected group of 15 affected individuals in the near, intermediate and far distance ranges perceive minimal, or no, ghosting at near, intermediate and far distances.

(C44) The lens of one or more C examples, wherein the lens is configured such that at least 60%, 70%, 80% or 90% of a randomly selected group of 15 affected individuals in the near, intermediate and far distance ranges perceive minimal, or no, ghosting at near, intermediate and far distances.

(C45) The lens of one or more C examples, wherein the single vision lens provides a visual acuity for the user of one or more of the following: at least 20/20, at least 20/30, at least 20/40, at least about 20/20, at least about 20/30 and at least about 20/40, at far visual distance.

(C46) The lens of one or more C examples, wherein the aberration profile is comprised of the defocus term and the at least two, two or more, three, three or more, four, four or more, five, five or more, six, six or more, seven, seven or more, eight, eight or more, ten, or ten or more spherical aberration terms.

(C47) The lens of one or more C examples, wherein the aberration profile is comprised of the defocus term and the at least two, three, four, five, six, seven, eight, or at least ten spherical aberration terms.

(C48) The multifocal lens of one or more C examples, wherein the aberration profile is comprised of a defocus term and spherical aberration terms between C(4,0) and C(6,0), C(4,0) and C(8,0), C(4,0) and C(10,0), C(4,0) and C(12,0), C(4,0) and C(14,0), C(4,0) and C(16,0), C(4,0) and C(18,0), or C(4,0) and C(20,0).

(C49) The lens of one or more C examples, wherein the best-corrected visual acuity is a visual acuity that cannot be substantially improved by further manipulating the power of the single vision lens.

(C50) The lens of one or more C examples, wherein the least one aberration profile is along the optical axis of the lens.

(C51) The lens of one or more C examples, wherein the aberration profile includes higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0).

(C52) The lens of one or more C examples, wherein the aberration profile provides, for a model eye with no aberrations and an on-axis length equal to the focal distance: the RIQ with a through focus slope that degrades in a direction of eye growth; and the RIQ of at least 0.30; wherein the RIQ is Visual Strehl Ratio measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(C53) The lens of one or more C examples, wherein the aberration profile provides, for a model eye with no aberrations and an on-axis length equal to the focal distance: the RIQ with a through focus slope that improves in a direction of eye growth; and the RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(C54) The lens of one or more C examples, wherein the lens has the optical axis and the aberration profile about the lens optical axis, the aberration profile: having the focal distance; and including higher order aberrations having the at least one of a primary spherical aberration component C(4,0) and the secondary spherical aberration component

C(6,0), wherein the aberration profile provides, for the model eye with no aberrations and an on-axis length equal to the focal distance: the RIQ with a through focus slope that degrades in a direction of eye growth; and the RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured along the optical axis for the at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(C55) The lens of one or more C examples, wherein the focal distance is a prescription focal distance for a myopic eye and wherein the focal distance differs from the focal distance for a C(2,0) Zernike coefficient of the aberration profile.

(C56) The lens of one or more C examples, wherein the higher order aberrations include at least two spherical aberration terms selected from the group C(4,0) to C(20,0).

(C57) The lens of one or more C examples, wherein the higher order aberrations include at least three spherical aberration terms selected from the group C(4,0) to C(20,0).

(C58) The lens of one or more C examples, wherein the higher order aberrations include at least five spherical aberration terms selected from the group C(4,0) to C(20,0).

(C59) The lens of one or more C examples, wherein the average slope over a horizontal field of at least -20° to +20° degrades in a direction of eye growth.

(C60) The lens of one or more C examples, wherein the average slope over a vertical field of at least -20° to +20° degrades in a direction of eye growth.

(C61) The lens of one or more C examples, wherein the slope for a substantial portion of the field angles over a horizontal field of at least -20° to +20° degrades in a direction of eye growth.

(C62) The lens of one or more C examples, wherein the substantial portion of the field angles over a horizontal field is every field angle.

(C63) The lens of one or more C examples, wherein the slope for a substantial portion of the field angles over a vertical field of at least -20° to +20° degrades in a direction of eye growth.

(C64) The lens of one or more C examples, wherein the substantial portion of the field angles over a vertical field is every angle.

(C65) The lens of one or more C examples, wherein the aberration profile provides the RIQ of at least 0.3 at the focal length for a substantial portion of pupil diameters in the range 3 mm to 6 mm.

(C66) The lens of one or more C examples, wherein the aberration profile provides the RIQ of at least 0.3 at the focal length for a substantial portion of pupil diameters in the range 4 mm to 5 mm.

(C67) The lens of one or more C examples, wherein the aberration profile provides the RIQ with a through focus slope that degrades in a direction of eye growth when primary astigmatism is added to the aberration profile.

(C68) The lens of one or more C examples, wherein the aberration profile provides the RIQ with a through focus slope that degrades in a direction of eye growth when secondary astigmatism is added to the aberration profile.

C.47. The lens of one or more C examples, wherein the RIQ is characterised by

$$RIQ = \frac{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}|^2))))}{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}|^2))))}$$

$$RIQ = \frac{\iint_{-Fmin}^{+Fmax} CSF(x,y) * \left(\left(\left(\left[FT\left(\left|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}\right|^2\right)\right)\right)\right)}{\iint_{-Fmin}^{+Fmax} CSF(x,y) * \left(\left(\left(\left[FT\left(\left|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}\right|^2\right)\right)\right)\right)},$$

wherein:

Fmin is 0 cycles/degree and *Fmax* is 30 cycles/degree;

CSF(x, y) denotes the contrast sensitivity function,

$CSF(F)=2.6(0.0192+0.114f)e^{-(0.114f)^{1.1}}$

where *f* specifies the tested spatial frequency, in the range of F_{min} to F_{max};

FT denotes a 2D fast Fourier transform;

A(ρ,θ) denotes the pupil diameter;

W(ρ,θ) denotes wavefront phase of the test case measured for i=1 to 20;

$$W(\rho,\theta) = \sum_{i=1}^{k} a_i Z_i(\rho,\theta)$$

Wdiff(ρ, θ) denotes wavefront phase of the diffraction limited case;

ρ and *θ* are normalised polar coordinates, where ρ represents the radial coordinate and θ represents the angular coordinate or azimuth; and

λ denotes wavelength.

(C69) The lens of one or more C examples, wherein the lens includes the optical axis and the aberration profile about the optical axis that provides: the focal distance for the C(2,0) Zernike coefficient term; a peak Visual Strehl Ratio ('first Visual Strehl Ratio') within a through focus range, and a Visual Strehl Ratio that remains at or above a second Visual Strehl Ratio over the through focus range that includes the focal distance, wherein the Visual Strehl Ratio is measured for the model eye with no aberration and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over the spatial frequency range of 0 to 30 cycles/degree inclusive, at the wavelength selected from within the range 540 nm to 590 nm inclusive, and wherein the first Visual Strehl Ratio is at least 0.35, the second Visual Strehl Ratio is at least 0.1 and the through focus range is at least 1.8 Dioptres.

(C70) The lens of one or more C examples, wherein the first Visual Strehl Ratio is at least 0.4, 0.5, 0.6, 0.7 or 0.8.

(C71) The lens of one or more C examples, wherein the second Visual Strehl Ratio is at least 0.1, 0.12, 0.14, 0.16, 0.18 or 0.2.

(C72) The lens of one or more C examples, wherein the through focus range is at least 1.7, 1.8, 1.9, 2, 2.1, 2.25 or 2.5 Dioptres.

(C73) The lens of one or more C examples, wherein the lens has a prescription focal distance located within 0.75, 0.5, 0.3, or 0.25 Dioptres, inclusive, of an end of the through focus range.

(C74) The lens of one or more C examples, wherein the end of the through focus range is the negative power end.

(C75) The lens of one or more C examples, wherein the end of the through focus range is the positive power end.

(C76) The lens of one or more C examples, wherein the Visual Strehl Ratio remains at or above the second Visual Strehl Ratio over the through focus range and over a range of pupil diameters of at least 1 mm, 1.5 mm or 2 mm.

(C77) The lens of one or more C examples, wherein the combination of higher order aberrations includes at least one of primary spherical aberration and secondary spherical aberration.

(C78) The lens of one or more C examples, wherein the higher order aberrations include at least two, three, or five spherical aberration terms selected from the group C(4,0) to C(20,0).

(C79) The lens of one or more C examples, wherein the aberration profile is substantially charactered using only spherical aberration Zernike coefficients C(4,0) to C(20,0).

(C80) The lens of one or more C examples, wherein the RIQ for a substantial portion of the angles over a horizontal field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.3, 0.35, or 0.4.

(C81) The lens of one or more C examples, wherein the RIQ for every angle over a horizontal field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.3, 0.35, or 0.4.

(C82) The lens of one or more C examples, wherein a first lens is provided based on one or more of the C examples and a second lens is provided based on one or more of the C examples to form a pair of lenses.

(C83) The lens of one or more C examples, wherein a first lens is provided based on one or more of the C examples and a second lens is provided to form a pair of lenses.

(C84) The lens of one or more C examples, wherein the pair of lenses are provide for use by an individual to substantially correct the individuals version.

Example set D:

(D1) A lens for an eye, the lens having at least one optical axis and at least one optical profile substantially about at least one optical axis, the optical profile comprising: at least one focal distance; and one or more higher order aberrations, wherein the optical profile provides for: a model eye with substantially no aberrations and an on-axis length equal to, or substantially equal to, the desired focal distance; a retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth; and a RIQ of at least 0.3; and wherein the RIQ is measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(D2) A lens for an eye, the lens having at least one optical axis and at least one optical profile substantially about at least one optical axis, the optical profile comprising: at least one focal distance; and one or more higher order aberrations, wherein the optical profile provides for: a model eye with no aberrations and an on-axis length equal to the desired focal distance; a retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth; and a RIQ of at least 0.3; and wherein the RIQ is measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial

frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(D3) A lens for an eye, the lens having an optical axis and at least one optical profile substantially about the optical axis the optical profile comprising: at least one focal distance; and one or more higher order aberrations, wherein the optical profile provides for: a model eye with substantially no aberrations and an on-axis length equal to, or substantially equal to, the desired focal distance; a retinal image quality (RIQ) with a through focus slope that improves in a direction of eye growth; and a RIQ of at least 0.3; and wherein the RIQ is measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(D4) A lens for an eye, the lens having an optical axis and an aberration profile about the optical axis the aberration profile comprising: a focal distance; and higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), wherein the aberration profile provides for: a model eye with no aberrations, or substantially no aberrations, and an on-axis length equal to the focal distance: a retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth; and a RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(D5) A lens for an eye, the lens having an optical axis and an aberration profile about the optical axis the aberration profile comprising: a focal distance; and higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), wherein the aberration profile provides for: a model eye with no aberrations and an on-axis length equal to the focal distance; a retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth; and a RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(D6) A lens for an eye, the lens having an optical axis and at least one optical profile substantially about the optical axis the optical profile comprising: at least one focal

distance; and one or more higher order aberrations, wherein the optical profile provides for: a model eye with substantially no aberrations an on-axis length equal to, or substantially equal to, the desired focal distance; a retinal image quality (RIQ) with a through focus slope that improves in a direction of eye growth; and a RIQ of at least 0.3; and wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(D7) A lens for an eye, the lens having an optical axis and an aberration profile about the optical axis the aberration profile comprising: a focal distance; and higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), wherein the aberration profile provides for: a model eye with no aberrations, or substantially no aberrations, and an on-axis length equal to the focal distance: a retinal image quality (RIQ) with a through focus slope that improves in a direction of eye growth; and a RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(D8) A lens for an eye, the lens having an optical axis and a surface structure, wherein the surface structure is configured to generate an aberration profile about the optical axis, the aberration profile comprising: a focal distance; and higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0),wherein the aberration profile provides, for a model eye with no aberrations, or substantially no aberrations, and an on-axis length equal to the focal distance: a retinal image quality (RIQ) with a through focus slope that improves in a direction of eye growth; and a RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(D9) A lens for an eye, the lens having an optical axis and at least one optical profile substantially about the optical axis, the optical profile comprising: at least one focal distance; and one or more higher order aberrations, wherein the optical profile provides, for a model eye with substantially no aberrations an on-axis length equal to, or

substantially equal to, the desired focal distance; a retinal image quality (RIQ) with a through focus slope that improves in a direction of eye growth; and a RIQ of at least 0.3; wherein said RIQ is measured substantially along the optical axis for at least one pupil.

(D10) The lens of one or more D examples, wherein the single-vision lens is one or more of the following: prescribed, appropriately prescribed, correctly prescribed and effectively prescribed.

(D11) The lens of one or more D examples, wherein the single-vision lens is a lens with a substantially constant power across a substantial portion of an optic zone of the single-vision lens.

(D12) The lens of one or more D examples, wherein the single-vision lens is a lens with a constant power across a portion of an optic zone of the single-vision lens.

(D13) The lens of one or more D examples, wherein the single-vision lens is a lens with a substantially constant power across a portion of one or more optic zones of the single-vision lens.

(D14) The lens of one or more D examples, wherein the lens is used for a presbyopic eye.

(D15) The lens of one or more D examples, wherein the lens is configured for a presbyopic eye.

(D16) The lens of one or more D examples, wherein the lens is configured to optically correct or substantially correct presbyopia.

(D17) The lens of one or more D examples, wherein the lens is configured to mitigate or substantially mitigate the optical consequences of presbyopia.

(D18) The lens of one or more D examples, wherein the lens is configured to alter or substantially alter a presbyopic condition to a non-presbyopic condition.

(D19) The lens of one or more D examples, wherein the lens is used for at least correcting a presbyopic eye condition and when used provides an appropriate correction to adjust the vision of the user towards substantially normal non-presbyopic vision.

(D20) The lens of one or more D examples, wherein normal vision is 6/6 or better.

(D21) The lens of one or more D examples, wherein the lens is further characterised by minimal, substantially no or no, ghosting at near, intermediate and far distances.

(D22) The lens of one or more D examples, wherein the lens is further characterised by minimal, substantially no or no, ghosting at near distances, intermediate distances and far distances.

(D23) The lens of one or more D examples, wherein the lens is further configured to provide minimal, substantially no or no, ghosting at near, intermediate and far distances.

(D24) The lens of one or more D examples, wherein the minimal ghosting is a lack of an undesired secondary image appearing at the image plane of the optical system.

(D25) The lens of one or more D examples, wherein the minimal ghosting is a lack of an undesired secondary image appearing on the retina of the eye.

(D26) The lens of one or more D examples, wherein the minimal ghosting is a lack of an undesired double image appearing on the retina of the eye.

(D27) The lens of one or more D examples, wherein the minimal ghosting is a lack of false out-of-focus image appearing along side of the primary image in an optical system.

(D28) The lens of one or more D examples, wherein the lens is further configured to provide a sufficient lack of ghosting in a portion of near, intermediate and far distances.

(D29) The lens of one or more D examples, wherein the lens is further configured to provide a sufficient lack of ghosting at near distances, intermediate distances and far distances.

(D30) The lens of one or more D examples, wherein the lens is further configured to provide a sufficient lack of ghosting in a portion of two or more of the following: near, intermediate and far distances.

(D31) The lens of one or more D examples, wherein lack of ghosting is lack of undesired image appearing at the image plane of the optical system.

(D32) The lens of one or more D examples, wherein lack of ghosting is a lack of false out of focus images appearing along side of the primary image in an optical system.

(D33) The lens of one or more D examples, wherein the lens is further configured to provide a sufficient lack of ghosting in a portion of two or more of the following: near distances, intermediate distances and far distances.

(D34) The lens of one or more D examples, wherein the lens is further configured to provide the RIQ of at least 0.1, 0.13, 0.17, 0.2, 0.225, or 0.25 in the near distance range, the RIQ of at least 0.27, 0.3, 0.33, 0.35, 0.37 or 0.4 in the intermediate distance range and the RIQ of at least 0.35, 0.37, 0.4, 0.42, 0.45, 0.47, or 0.5 in the far distance range.

(D35) The lens of one or more D examples, wherein the lens is further configured to provide two or more of the following: the RIQ of at least 0.1, 0.13, 0.17, 0.2, 0.225, or 0.25 in the near distance range, the RIQ of at least 0.27, 0.3, 0.33, 0.35, 0.37 or 0.4 in the intermediate distance range and the RIQ of at least 0.35, 0.37, 0.4, 0.42, 0.45, 0.47, or 0.5 in the far distance range.

(D36) The lens of one or more D examples, wherein the RIQs are selected in the near, intermediate and far distance ranges such that the lens is configured to provide minimal, or no, ghosting in near, intermediate and far distances.

(D37) The lens of one or more D examples, wherein the lens is configured to substantially eliminate, or substantially reduce, ghosting at near, intermediate and far distances.

(D38) The lens of one or more D examples, wherein the lens is configured to substantially eliminate, or substantially reduce, ghosting at near distances, intermediate distances and far distances.

(D39) The lens of one or more D examples, wherein near distance is the range of 33 cm to 50 cm or 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm, 50 cm to 80 cm or 50 cm to 70 cm; and far distance is the range of 100 cm or greater, 80 cm or greater or 70 cm or greater.

(D40) The lens of one or more D examples, wherein near distance is the range of 33 cm to 50 cm or 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm, 50 cm to 80 cm or 50 cm to 70 cm; and far distance is the range of 100 cm or greater, 80 cm or greater or 70 cm or greater and the near, intermediate and far distances are determined by the distance from the object being focused on.

(D41) The lens of one or more D examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm or greater.

(D42) The lens of one or more D examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm or greater and the near, intermediate and far distances are determined by the distance from the object being focused on.

(D43) The lens of one or more D examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm to optical infinity.

(D44) The lens of one or more D examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm to optical infinity and the near, intermediate and far distances are determined by the distance from the object being focused on.

(D45) The lens of one or more D examples, wherein the lens is configured to minimize, or reduce, ghosting at near, intermediate and far distances when used on an eye.

(D46) The lens of one or more D examples, wherein the lens is configured to minimize, or reduce, ghosting at near distances, intermediate distances and far distances when used on an eye.

(D47) The lens of one or more D examples, wherein the range of substantially continuous distances is continuous.

(D48) The lens of one or more D examples, wherein the range of substantially continuous distances is continuous and goes from 40 cm to optical infinity.

(D49) The lens of one or more D examples, wherein the range of substantially continuous distances is from 33 cm to optical infinity.

(D50) The lens of one or more D examples, wherein the lens is configured such that at least 40%, 50%, 60% or 70% of a randomly selected group of 15 affected individuals in the near distances, intermediate distances and far distances perceive minimal, or no, ghosting at near distances, intermediate distances and far distances.

(D51) The lens of one or more D examples, wherein the lens is configured such that at least 60%, 70%, 80% or 90% of a randomly selected group of 15 affected individuals in the intermediate distances and far distances perceive minimal, or no, ghosting at intermediate distances and far distances.

(D52) The lens of one or more D examples, wherein the single vision lens provides a visual acuity for the user of one or more of the following: at least 20/20, at least 20/30, at least 20/40, at least about 20/20, at least about 20/30 and at least about 20/40, at far visual distances.

(D53) The lens of one or more D examples, wherein the aberration profile is comprised of a defocus term and at least two, two or more, three, three or more, four, four or more, five, five or more, six, six or more, seven, seven or more, eight, eight or more, nine, nine or more, ten, or ten or more spherical aberration terms.

(D54) The lens of one or more D examples, wherein the aberration profile is comprised of a defocus term and at least two, three, four, five, six, seven, eight, nine, or at least ten spherical aberration terms.

(D55) The lens of one or more D examples, wherein the aberration profile is comprised of a defocus term and spherical aberration terms between C(4,0) and C(6,0), C(4,0) and C(8,0), C(4,0) and C(10,0), C(4,0) and C(12,0), C(4,0) and C(14,0), C(4,0) and C(16,0), C(4,0) and C(18,0), or C(4,0) and C(20,0).

(D56) The lens of one or more D examples, wherein the single vision lens provides a visual acuity that is the best-corrected visual acuity.

(D57) The lens of one or more D examples, wherein the best-corrected visual acuity is a visual acuity that cannot be substantially improved by further manipulating the power of the single vision lens.

(D58) The lens of one or more D examples, wherein the lens has two optical surfaces.

(D59) The lens of one or more D examples, wherein the least one aberration profile is along the optical axis of the lens.

(D60) The lens of one or more D examples, wherein the lens has a focal distance.

(D61) The lens of one or more D examples, wherein the aberration profile includes higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0).

(D62) The lens of one or more D examples, wherein the focal distance is a prescription focal distance for a myopic, hyperopic, astigmatic, and/or presbyopic eye and wherein the focal distance differs from the focal distance for a C(2,0) Zernike coefficient of the aberration profile.

(D63) The lens of one or more D examples, wherein the higher order aberrations include at least two spherical aberration terms selected from the group C(4,0) to C(20,0).

(D64) The lens of one or more D examples, wherein the higher order aberrations include at least three spherical aberration terms selected from the group C(4,0) to C(20,0).

(D65) The lens of one or more D examples, wherein the higher order aberrations include at least five spherical aberration terms selected from the group C(4,0) to C(20,0).

(D66) The lens of one or more D examples, wherein the average slope over a horizontal field of at least -20° to +20° degrades in a direction of eye growth.

(D67) The lens of one or more D examples, wherein the minimal ghosting is a lack of an undesired secondary image appearing at the image plane of the optical system.

(D68) The lens of one or more D examples, wherein the minimal ghosting is a lack of an undesired secondary image appearing on the retina of the eye.

(D69) The lens of one or more D examples, wherein the minimal ghosting is a lack of an undesired double image appearing on the retina of the eye.

(D70) The lens of one or more D examples, wherein the minimal ghosting is a lack of false out-of-focus image appearing along side of the primary image in an optical system.

(D71) The lens of one or more D examples, wherein the average slope over a horizontal field of at least -20° to +20° improves in a direction of eye growth.

(D72) The lens of one or more D examples, wherein the average slope over a vertical field of at least -20° to +20° degrades in a direction of eye growth.

(D73) The lens of one or more D examples, wherein the average slope over a vertical field of at least -20° to +20° improves in a direction of eye growth.

(D74) The lens of one or more D examples, wherein the slope for a substantial portion of the field angles over a horizontal field of at least -20° to +20° degrades in a direction of eye growth.

(D75) The lens of one or more D examples, wherein the substantial portion of the field angles over a horizontal field is at least 75%, 85%, 95% or 99% of the field angles.

(D76) The lens of one or more D examples, wherein the substantial portion of the field angles over a horizontal field is every field angle.

(D77) The lens of one or more D examples, wherein the slope for a substantial portion of the field angles over a vertical field of at least -20° to +20° degrades in a direction of eye growth.

(D78) The lens of one or more D examples, wherein the substantial portion of the field angles over a vertical field is every angle.

(D79) The lens of one or more D examples, wherein the substantial portion of the field angles over a vertical field is at least 75%, 85%, 95% or 99% of the field angles.

(D80) The lens of one or more D examples, wherein the aberration profile provides the RIQ of at least 0.3 at the focal length for a substantial portion of pupil diameters in the range 3 mm to 6 mm.

(D81) The lens of one or more D examples, wherein the aberration profile provides the RIQ of at least 0.3 at the focal length for a substantial portion of pupil diameters in the range 4 mm to 5 mm.

(D82) The lens of one or more D examples, wherein the aberration profile provides the RIQ with a through focus slope that degrades in a direction of eye growth when primary or secondary astigmatism is added to the aberration profile.

(D83) The lens of one or more D examples, wherein the aberration profile provides the RIQ with a through focus slope that improves in a direction of eye growth when primary or secondary astigmatism is added to the aberration profile.

(D84) The lens of one or more D examples, wherein the primary or secondary astigmatism is added to the desired aberration profile by altering one or more of the following terms: C(2,-2), C(2,2), C(4,-2), C(4,2), C(6,-2), and/or C(6,2).

(D85) The lens of one or more D examples, wherein the aberration profile provides the RIQ with a through focus slope that degrades in a direction of eye growth when secondary astigmatism is added to the aberration profile.

(D86) The lens of one or more D examples, wherein the secondary astigmatism is added to the desired aberration profile by altering one or more of the following terms: C(2,-2), C(2,2), C(4,-2), C(4,2), C(6,-2), and/or C(6,2).

(D87) The lens of one or more D examples, wherein the RIQ is characterised by

$$RIQ = \frac{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}|^2))))}{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}|^2))))},$$

wherein:

Fmin is 0 cycles/degree and *Fmax* is 30 cycles/degree;

CSF(x, y) denotes the contrast sensitivity function,

$CSF(F)=2.6(0.0192+0.114f)e^{-(0.114f)^{1.1}}$,

where *f* specifies the tested spatial frequency, in the range of F_{min} to F_{max};

FT denotes a 2D fast Fourier transform;

$A(\rho,\theta)$ denotes the pupil diameter;

$W(\rho,\theta)$ denotes wavefront phase of the test case measured for i=1 to 20

$$W(\rho,\theta) = \sum_{i=1}^{k} a_i Z_i(\rho,\theta);$$

$Wdiff(\rho, \theta)$ denotes wavefront phase of the diffraction limited case;

ρ and θ are normalised polar coordinates, where ρ represents the radial coordinate and θ represents the angular coordinate or azimuth; and

λ denotes wavelength.

(D88) The lens of one or more D examples, wherein the lens includes an optical axis and an aberration profile along the optical axis that provides: a focal distance for a C(2,θ) Zernike

coefficient term; a peak Visual Strehl Ratio ('first Visual Strehl Ratio') within a through focus range, and a Visual Strehl Ratio that remains at or above a second Visual Strehl Ratio over the through focus range that includes said focal distance, wherein the Visual Strehl Ratio is measured for a model eye with no, or substantially no, aberration and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a wavelength selected from within the range 540 nm to 590 nm inclusive, and wherein the first Visual Strehl Ratio is at least 0.35, the second Visual Strehl Ratio is at least 0.1 and the through focus range is at least 1.8 Dioptres.

(D89) The lens of one or more D examples, wherein the lens includes an optical axis and an aberration profile along the optical axis that provides: a focal distance for a C(2,0) Zernike coefficient term; a peak Visual Strehl Ratio ('first Visual Strehl Ratio') within a through focus range, and a Visual Strehl Ratio that remains at or above a second Visual Strehl Ratio over the through focus range that includes said focal distance, wherein the Visual Strehl Ratio is measured for a model eye with no aberration and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a wavelength selected from within the range 540 nm to 590 nm inclusive, and wherein the first Visual Strehl Ratio is at least 0.35, the second Visual Strehl Ratio is at least 0.1 and the through focus range is at least 1.8 Dioptres.

(D90) The lens of one or more D examples, wherein the first Visual Strehl Ratio is at least 0.3, 0.35, 0.4, 0.5, 0.6, 0.7 or 0.8.

(D91) The lens of one or more D examples, wherein the second Visual Strehl Ratio is at least 0.1, 0.12, 0.15, 0.18 or 0.2.

(D92) The lens of one or more D examples, wherein the through focus range is at least 1.7, 1.8, 1.9, 2, 2.1, 2.25 or 2.5 Dioptres.

(D93) The lens of one or more D examples, wherein the lens has a prescription focal distance located within 0.75, 0.5, 0.3, or 0.25 Dioptres, inclusive, of an end of the through focus range.

(D94) The lens of one or more D examples, wherein the end of the through focus range is the negative power end.

(D95) The lens of one or more D examples, wherein the end of the through focus range is the positive power end.

(D96) The lens of one or more D examples, wherein the Visual Strehl Ratio remains at or above the second Visual Strehl Ratio over the through focus range and over a range of pupil diameters of at least 1 mm, 1.5 mm, 2 mm, 2.5 mm, or 3 mm.

(D97) The lens of one or more D examples, wherein the combination of higher order aberrations includes at least one of primary spherical aberration and secondary spherical aberration.

(D98) The lens of one or more D examples, wherein the higher order aberrations include at least two, three, or five spherical aberration terms selected from the group C(4,0) to C(20,0).

(D99) The lens of one or more D examples, wherein the aberration profile is substantially charactered using only spherical aberration Zernike coefficients C(4,0) to C(20,0).

(D100) The lens of one or more D examples, wherein the RIQ for a substantial portion of the angles over a horizontal field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.4.

(D101) The lens of one or more D examples, wherein the RIQ for a substantial portion of the angles over a horizontal field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.35.

(D102) The lens of one or more D examples, wherein the RIQ for a substantial portion of the angles over a horizontal field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.3.

(D103) The lens of one or more D examples, wherein the lens is one or more of the following: contact lens, corneal onlays, corneal inlays, anterior chamber intraocular lens or posterior chamber intraocular lens.

(D104) The lens of one or more D examples, wherein the lens is one of the following: contact lens, corneal onlays, corneal inlays, anterior chamber intraocular lens or posterior chamber intraocular lens.

(D105) The lens of one or more D examples, wherein a first lens is provided based on one or more of the D examples and a second lens is provided based on one or more of the D examples to form a pair of lenses.

(D106) The lens of one or more D examples, wherein the first lens is provided based on one or more of the D examples and a second lens is provided to form a pair of lenses.

(D107) The lens of one or more D examples, wherein a pair of lenses are provided for use by an individual to substantially correct the individual's vision.

(D108) A method for making or using one or more of the lenses of one or more D examples.

(D109) The lens of one or more D examples, wherein the lens does not substantially reduce the amount of light passing through the lens.

(D110) The lens of one or more D examples, wherein the amount of light passing through the lens is at least 80%, 85%, 90%, 95% or 99%.

Example set E:

(E1) A lens for an eye, the lens comprising: an optical axis; an aberration profile about the optical axis and having a focal distance; and at least two optical surfaces; and wherein the lens's optical properties can be characterised upon testing by at least the following properties: two or more higher order aberrations having one or more of the following components: a primary spherical aberration C(4,0), a secondary spherical aberration C(6,0), a tertiary spherical aberration C(8,0), a quaternary spherical aberration C(10,0), a pentanary spherical aberration C(12,0), a hexanary spherical aberration C(14,0), a heptanary spherical aberration C(16,0), an octanary spherical aberration C(18,0) and a nanonary spherical aberration C(20,0); the aberration profile when tested on a model eye with no, or substantially no, aberrations and having an on-axis length equal, or substantially equal, to the focal distance, results in a retinal image quality (RIQ) with a through focus slope so that the RIQ decreases in a direction of eye growth, where the RIQ is determined by a Visual Strehl Ratio that is measured substantially along the optical axis; and the RIQ is measured for a model eye with no, or substantially no, aberration and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(E2) A lens for an eye, the lens comprising: an optical axis; an aberration profile about the optical axis and having a focal distance; and at least two optical surfaces; and wherein the lens's optical properties can be characterised upon testing by at least the following properties: two or more higher order aberrations having one or more of the following components: a primary spherical aberration C(4,0), a secondary spherical aberration C(6,0), a tertiary spherical aberration C(8,0), a quaternary spherical aberration C(10,0), a pentanary spherical aberration C(12,0), a hexanary spherical aberration C(14,0), a heptanary spherical aberration C(16,0), an octanary spherical aberration C(18,0) and a nanonary spherical aberration C(20,0); the aberration profile when tested on a model eye

with no aberrations and having an on-axis length equal to the focal distance, results in a retinal image quality (RIQ) with a through focus slope so that the RIQ decreases in a direction of eye growth, where the RIQ is determined by a Visual Strehl Ratio that is measured along the optical axis; and the RIQ is measured for a model eye with no aberrations and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(E3) A lens for an eye, the lens comprising: an optical axis; an aberration profile about the optical axis and having a focal distance; and at least two optical surfaces; and wherein the lens's optical properties can be characterised upon testing by at least the following properties: two or more higher order aberrations having one or more of the following components: a primary spherical aberration C(4,0), a secondary spherical aberration C(6,0), a tertiary spherical aberration C(8,0), a quaternary spherical aberration C(10,0), a pentanary spherical aberration C(12,0), a hexanary spherical aberration C(14,0), a heptanary spherical aberration C(16,0), an octanary spherical aberration C(18,0) and a nanonary spherical aberration C(20,0); the aberration profile when tested on a model eye with no aberrations and having an on-axis length equal to the focal distance, results in a retinal image quality (RIQ) with a through focus slope so that the RIQ increases in a direction of eye growth, where the RIQ is determined by a Visual Strehl Ratio that is measured along the optical axis; and the RIQ is measured for a model eye with no aberrations and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(E4) A lens for an eye, the lens comprising: an optical axis; an aberration profile about the optical axis and having a focal distance; and at least two optical surfaces; and wherein the lens's optical properties can be characterised upon testing by at least the following properties: two or more higher order aberrations having one or more of the following components: a primary spherical aberration C(4,0), a secondary spherical aberration C(6,0), a tertiary spherical aberration C(8,0), a quaternary spherical aberration C(10,0), a pentanary spherical aberration C(12,0), a hexanary spherical aberration C(14,0), a heptanary spherical aberration C(16,0), an octanary spherical aberration C(18,0) and a nanonary spherical aberration C(20,0); the aberration profile when tested on a model eye with no, or substantially no, aberrations and having an on-axis length equal, or

substantially equal, to the focal distance, results in a retinal image quality (RIQ) with a through focus slope so that the RIQ increases in a direction of eye growth, where the RIQ is determined by a Visual Strehl Ratio that is measured substantially along the optical axis; and the RIQ is measured for a model eye with no, or substantially no, aberration and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(E5) A lens for an eye, the lens comprising: an optical axis; an aberration profile about the optical axis and having a focal distance; and at least two optical surfaces; and wherein the lens's optical properties can be characterised upon testing by at least the following properties: two or more higher order aberrations having one or more of the following components: a primary spherical aberration C(4,0), a secondary spherical aberration C(6,0), a tertiary spherical aberration C(8,0), a quaternary spherical aberration C(10,0), a pentanary spherical aberration C(12,0), a hexanary spherical aberration C(14,0), a heptanary spherical aberration C(16,0), an octanary spherical aberration C(18,0) and a nanonary spherical aberration C(20,0); the aberration profile when tested on a model eye with no, or substantially no, aberrations and having an on-axis length equal, or substantially equal, to the focal distance, results in a through focus RIQ, within the through focus range, a first RIQ which is a peak RIQ and that remains at or above a second RIQ over the through focus range that includes the focal distance; and the first and second RIQs are measured for a model eye with no, or substantially no, aberration and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(E6) A lens for an eye, the lens comprising: an optical axis; an aberration profile about the optical axis and having a focal distance; and at least two optical surfaces; and wherein the lens's optical properties can be characterised upon testing by at least the following properties: two or more higher order aberrations having one or more of the following components: a primary spherical aberration C(4,0), a secondary spherical aberration C(6,0), a tertiary spherical aberration C(8,0), a quaternary spherical aberration C(10,0), a pentanary spherical aberration C(12,0), a hexanary spherical aberration C(14,0), a heptanary spherical aberration C(16,0), an octanary spherical aberration C(18,0) and a nanonary spherical aberration C(20,0); the aberration profile when tested on a model eye

with no aberrations and having an on-axis length equal to the focal distance, results in a through focus RIQ, within the through focus range, a first RIQ which is a peak RIQ and that remains at or above a second RIQ over the through focus range that includes the focal distance; and the first and second RIQs are measured for a model eye with no aberration and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(E7) The lens of one or more E examples, wherein the single-vision lens is one or more of the following: prescribed, appropriately prescribed, correctly prescribed and effectively prescribed.

(E8) The lens of one or more E examples, wherein the lens does not substantially reduce the amount of light passing through the lens.

(E9) The lens of one or more E examples, wherein the amount of light passing through the lens is at least 80%, 85%, 90%, 95% or 99%.

(E10) The lens of one or more E examples, wherein the single-vision lens is a lens with a substantially constant power across a substantial portion of an optic zone of the single-vision lens.

(E11) The lens of one or more E examples, wherein the single-vision lens is a lens with a constant power across a portion of an optic zone of the single-vision lens.

(E12) The lens of one or more E examples, wherein the single-vision lens is a lens with a substantially constant power across a portion of one or more optic zones of the single-vision lens.

(E13) The lens of one or more E examples, wherein the lens is further characterised by minimal, substantially no or no, ghosting at near, intermediate and far distances.

(E14) The lens of one or more E examples, wherein the lens is further characterised by minimal, substantially no or no, ghosting at near distances, intermediate distances and far distances.

(E15) The lens of one or more E examples, wherein the lens is further configured to provide minimal, substantially no or no, ghosting at near, intermediate and far distances.

(E16) The lens of one or more E examples, wherein the minimal ghosting is a lack of an undesired secondary image appearing at the image plane of the optical system.

(E17) The lens of one or more E examples, wherein the minimal ghosting is a lack of an undesired secondary image appearing on the retina of the eye.

(E18) The lens of one or more E examples, wherein the minimal ghosting is a lack of an undesired double image appearing on the retina of the eye.

(E19) The lens of one or more E examples, wherein the minimal ghosting is a lack of false out-of-focus image appearing along side of the primary image in an optical system.

(E20) The lens of one or more E examples, wherein the lens is further configured to provide a sufficient lack of ghosting in a portion of near, intermediate and far distances.

(E21) The lens of one or more E examples, wherein the lens is further configured to provide a sufficient lack of ghosting at near distances, intermediate distances and far distances.

(E22) The lens of one or more E examples, wherein the lens is further configured to provide a sufficient lack of ghosting in a portion of two or more of the following: near, intermediate and far distances.

(E23) The lens of one or more E examples, wherein lack of ghosting is lack of undesired image appearing at the image plane of the optical system.

(E24) The lens of one or more E examples, wherein lack of ghosting is a lack of false out of focus images appearing along side of the primary image in an optical system.

(E25) The lens of one or more E examples, wherein the lens is further configured to provide a sufficient lack of ghosting in a portion of two or more of the following: near distances, intermediate distances and far distances.

(E26) The lens of one or more E examples, wherein the lens is further configured to provide the RIQ of at least 0.1, 0.13, 0.17, 0.2, 0.225, or 0.25 in the near distance range, the RIQ of at least 0.27, 0.3, 0.33, 0.35, 0.37 or 0.4 in the intermediate distance range and the RIQ of at least 0.35, 0.37, 0.4, 0.42, 0.45, 0.47, or 0.5 in the far distance range.

(E27) The lens of one or more E examples, wherein the lens is further configured to provide two or more of the following: the RIQ of at least 0.1, 0.13, 0.17, 0.2, 0.225, or 0.25 in the near distance range, the RIQ of at least 0.27, 0.3, 0.33, 0.35, 0.37 or 0.4 in the intermediate distance range and the RIQ of at least 0.35, 0.37, 0.4, 0.42, 0.45, 0.47, or 0.5 in the far distance range.

(E28) The lens of one or more E examples, wherein the RIQs are selected in the near, intermediate and far distance ranges such that the lens is configured to provide minimal, or no, ghosting in near, intermediate and far distances.

(E29) The lens of one or more E examples, wherein the lens is configured to substantially eliminate, or substantially reduce, ghosting at near, intermediate and far distances.

(E30) The lens of one or more E examples, wherein the lens is configured to substantially eliminate, or substantially reduce, ghosting at near distances, intermediate distances and far distances.

(E31) The lens of one or more E examples, wherein near distance is the range of 33 cm to 50 cm or 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm, 50 cm to 80 cm or 50 cm to 70 cm; and far distance is the range of 100 cm or greater, 80 cm or greater or 70 cm or greater.

(E32) The lens of one or more E examples, wherein near distance is the range of 33 cm to 50 cm or 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm, 50 cm to 80 cm or 50 cm to 70 cm; and far distance is the range of 100 cm or greater, 80 cm or greater or 70 cm or greater and the near, intermediate and far distances are determined by the distance from the object being focused on.

(E33) The lens of one or more E examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm or greater.

(E34) The lens of one or more E examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm or greater and the near, intermediate and far distances are determined by the distance from the object being focused on.

(E35) The lens of one or more E examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm to optical infinity.

(E36) The lens of one or more E examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm to optical infinity and the near, intermediate and far distances are determined by the distance from the object being focused on.

(E37) The lens of one or more E examples, wherein the lens is configured to minimize, or reduce, ghosting at near, intermediate and far distances when used on an eye.

(E38) The lens of one or more E examples, wherein the lens is configured to minimize, or reduce, ghosting at near distances, intermediate distances and far distances when used on an eye.

(E39) The lens of one or more E examples, wherein the range of substantially continuous distances is continuous.

(E40) The lens of one or more E examples, wherein the range of substantially continuous distances is continuous and goes from 40 cm to optical infinity.

(E41) The lens of one or more E examples, wherein the range of substantially continuous distances is from 33 cm to optical infinity.

(E42) The lens of one or more E examples, wherein the lens is configured such that at least 40%, 50%, 60% or 70% of a randomly selected group of 15 affected individuals in the near distances, intermediate distances and far distances perceive minimal, or no, ghosting at near distances, intermediate distances and far distances.

(E43) The lens of one or more E examples, wherein the lens is configured such that at least 60%, 70%, 80% or 90% of a randomly selected group of 15 affected individuals in the intermediate distances and far distances perceive minimal, or no, ghosting at intermediate distances and far distances.

(E44) The lens of one or more E examples, wherein the single vision lens provides a visual acuity for the user of one or more of the following: at least 20/20, at least 20/30, at least 20/40, at least about 20/20, at least about 20/30 and at least about 20/40, at far visual distances.

(E45) The lens of one or more E examples, wherein the aberration profile is comprised of a defocus term and at least two, two or more, three, three or more, four, four or more, five, five or more, six, six or more, seven, seven or more, eight, eight or more, nine, nine or more, ten, or ten or more spherical aberration terms.

(E46) The lens of one or more E examples, wherein the aberration profile is comprised of a defocus term and at least two, three, four, five, six, seven, eight, nine, or at least ten spherical aberration terms.

(E47) The lens of one or more E examples, wherein the aberration profile is comprised of a defocus term and spherical aberration terms between C(4,0) and C(6,0), C(4,0) and C(8,0), C(4,0) and C(10,0), C(4,0) and C(12,0), C(4,0) and C(14,0), C(4,0) and C(16,0), C(4,0) and C(18,0), or C(4,0) and C(20,0).

(E48) The lens of one or more E examples, wherein the single vision lens provides a visual acuity that is the best-corrected visual acuity.

(E49) The lens of one or more E examples, wherein the best-corrected visual acuity is a visual acuity that cannot be substantially improved by further manipulating the power of the single vision lens.

(E50) The lens of one or more E examples, wherein the lens has two optical surfaces.

(E51) The lens of one or more E examples, wherein the least one aberration profile is along the optical axis of the lens.

(E52) The lens of one or more E examples, wherein the lens has a focal distance.

(E53) The lens of one or more E examples, wherein the aberration profile includes higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0).

(E54) The lens of one or more E examples, wherein the focal distance is a prescription focal distance for a myopic, hyperopic, astigmatic, and/or presbyopic eye and wherein the focal distance differs from the focal distance for a C(2,0) Zernike coefficient of the aberration profile.

(E55) The lens of one or more E examples, wherein the higher order aberrations include at least two spherical aberration terms selected from the group C(4,0) to C(20,0).

(E56) The lens of one or more E examples, wherein the higher order aberrations include at least three spherical aberration terms selected from the group C(4,0) to C(20,0).

(E57) The lens of one or more E examples, wherein the higher order aberrations include at least five spherical aberration terms selected from the group C(4,0) to C(20,0).

(E58) The lens of one or more E examples, wherein the average slope over a horizontal field of at least -20° to +20° degrades in a direction of eye growth.

(E59) The lens of one or more E examples, wherein the average slope over a horizontal field of at least -20° to +20° improves in a direction of eye growth.

(E60) The lens of one or more E examples, wherein the average slope over a vertical field of at least -20° to +20° degrades in a direction of eye growth.

(E61) The lens of one or more E examples, wherein the average slope over a vertical field of at least -20° to +20° improves in a direction of eye growth.

(E62) The lens of one or more E examples, wherein the slope for a substantial portion of the field angles over a horizontal field of at least -20° to +20° degrades in a direction of eye growth.

(E63) The lens of one or more E examples, wherein the substantial portion of the field angles over a horizontal field is at least 75%, 85%, 95% or 99% of the field angles.

(E64) The lens of one or more E examples, wherein the substantial portion of the field angles over a horizontal field is every field angle.

(E65) The lens of one or more E examples, wherein the slope for a substantial portion of the field angles over a vertical field of at least -20° to +20° degrades in a direction of eye growth.

(E66) The lens of one or more E examples, wherein the substantial portion of the field angles over a vertical field is every angle.

(E67) The lens of one or more E examples, wherein the substantial portion of the field angles over a vertical field is at least 75%, 85%, 95% or 99% of the field angles.

(E68) The lens of one or more E examples, wherein the aberration profile provides the RIQ of at least 0.3 at the focal length for a substantial portion of pupil diameters in the range 3 mm to 6 mm.

(E69) The lens of one or more E examples, wherein the aberration profile provides the RIQ of at least 0.3 at the focal length for a substantial portion of pupil diameters in the range 4 mm to 5 mm.

(E70) The lens of one or more E examples, wherein the aberration profile provides the RIQ with a through focus slope that degrades in a direction of eye growth when primary or secondary astigmatism is added to the aberration profile.

(E71) The lens of one or more E examples, wherein the aberration profile provides the RIQ with a through focus slope that improves in a direction of eye growth when primary or secondary astigmatism is added to the aberration profile.

(E72) The lens of one or more E examples, wherein the primary or secondary astigmatism is added to the desired aberration profile by altering one or more of the following terms: C(2,-2), C(2,2), C(4,-2), C(4,2), C(6,-2), and/or C(6,2).

(E73) The lens of one or more E examples, wherein the aberration profile provides the RIQ with a through focus slope that degrades in a direction of eye growth when secondary astigmatism is added to the aberration profile.

(E74) The lens of one or more E examples, wherein the secondary astigmatism is added to the desired aberration profile by altering one or more of the following terms: C(2,-2), C(2,2), C(4,-2), C(4,2), C(6,-2), and/or C(6,2).

(E75) The lens of one or more E examples, wherein the RIQ is characterised by

$$RIQ = \frac{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}|^2))))}{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}|^2))))},$$

wherein:

Fmin is 0 cycles/degree and *Fmax* is 30 cycles/degree;

CSF(x, y) denotes the contrast sensitivity function $CSF(F)=2.6(0.0192+0.114f)e^{-(0.114f)^{1.1}}$, where *f* specifies the tested spatial frequency, in the range of F_{min} to F_{max};

FT denotes a 2D fast Fourier transform;

$A(\rho,\theta)$ denotes the pupil diameter;

$W(\rho,\theta)$ denotes wavefront phase of the test case measured for i=1 to 20

$$W(\rho,\theta) = \sum_{i=1}^{k} a_i Z_i(\rho,\theta) \quad ;$$

$Wdiff(\rho, \theta)$ denotes wavefront phase of the diffraction limited case;

ρ and θ are normalised polar coordinates, where ρ represents the radial coordinate and θ represents the angular coordinate or azimuth; and

λ denotes wavelength.

(E76) The lens of one or more E examples, wherein the first Visual Strehl Ratio is at least 0.3, 0.35, 0.4, 0.5, 0.6, 0.7 or 0.8.

(E77) The lens of one or more E examples, wherein the second Visual Strehl Ratio is at least 0.1, 0.12, 0.15, 0.18 or 0.2.

(E78) The lens of one or more E examples, wherein the through focus range is at least 1.7, 1.8, 1.9, 2, 2.1, 2.25 or 2.5 Dioptres.

(E79) The lens of one or more E examples, wherein the lens has a prescription focal distance located within 0.75, 0.5, 0.3, or 0.25 Dioptres, inclusive, of an end of the through focus range.

(E80) The lens of one or more E examples, wherein the end of the through focus range is the negative power end.

(E81) The lens of one or more E examples, wherein the end of the through focus range is the positive power end.

(E82) The lens of one or more E examples, wherein the Visual Strehl Ratio remains at or above the second Visual Strehl Ratio over the through focus range and over a range of pupil diameters of at least 1 mm, 1.5 mm, 2 mm, 2.5 mm, or 3 mm.

(E83) The lens of one or more E examples, wherein the combination of higher order aberrations includes at least one of primary spherical aberration and secondary spherical aberration.

(E84) The lens of one or more E examples, wherein the higher order aberrations include at least two, three, or five spherical aberration terms selected from the group C(4,0) to C(20,0).

(E85) The lens of one or more E examples, wherein the higher order aberrations include at least six, seven or eight spherical aberration terms selected from the group C(4,0) to C(20,0).

(E86) The lens of one or more E examples, wherein the aberration profile is capable of being characterised using only spherical aberration Zernike coefficients C(4,0) to C(20,0).

(E87) The lens of one or more E examples, wherein the RIQ for a substantial portion of the angles over a horizontal field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.3, 0.35 or 0.4.

(E88) The lens of one or more E examples, wherein the RIQ for a substantial portion of the angles over a vertical field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.3, 0.35 or 0.4.

(E89) The lens of one or more E examples, wherein the RIQ for a substantial portion of the angles over a horizontal field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.3.

(E90) The lens of one or more E examples, wherein the lens is one or more of the following: contact lens, corneal onlays, corneal inlays, anterior chamber intraocular lens or posterior chamber intraocular lens.

(E91) The lens of one or more E examples, wherein the lens is one of the following: contact lens, corneal onlays, corneal inlays, anterior chamber intraocular lens or posterior chamber intraocular lens.

(E92) The lens of one or more E examples, wherein a first lens is provided based on one or more of the E examples and a second lens is provided based on one or more of the E examples to form a pair of lenses.

(E93) The lens of one or more E examples, wherein the first lens is provided based on one or more of the E examples and a second lens is provided to form a pair of lenses.

(E94) The lens of one or more E examples, wherein a pair of lenses are provided for use by an individual to substantially correct the individual's vision.

(E95) A method for making or using one or more of the lenses of one or more E examples.

Examples set F:

(F1) A lens comprising: an optical axis; an aberration profile about the optical axis and having a focal distance; at least two optical surfaces; an aperture size greater than 2 mm; wherein the lens is configured such that the lens is characterised by one or more power profiles and the one or more power profiles provide a lens that has the following properties: the visual performance of the multifocal lens at near, intermediate and far visual distances is substantially equivalent to or better than an appropriately prescribed single-vision lens for far visual distance and produces minimal ghosting at distances from far distance to near.

(F2) A lens comprising: an optical axis; an aberration profile having a focal distance; and at least two optical surfaces; wherein the lens is configured at least in part by one or more power profiles and the lens has the following properties: the visual performance of the lens at near, intermediate and far visual distances is substantially equivalent to, or better than, an appropriately prescribed single-vision lens for far visual distance and produces minimal ghosting at distances from far distance to near.

(F3) A lens comprising: an optical axis; an aberration profile having a focal distance; at least two optical surfaces; wherein the lens is configured at least in part by one or more power profiles and the lens has the following properties: the visual performance of the lens at intermediate and far visual distances is substantially equivalent to, or better than, a properly prescribed single-vision lens for far visual distance and produces minimal ghosting at distances from far distance to near.

(F4) A lens comprising: an optical axis; an aberration profile having a focal distance; at least two optical surfaces; the lens is configured by one or more power profiles and has the following lens properties: the lens is capable of decreasing the rate of progression of myopia; the lens is capable of decreasing the rate of growth of the eye as measured by axial length; and provides visual performance at intermediate and far visual distances that is at least substantially equivalent to a properly prescribed single-vision lens for far visual distance and produces minimal ghosting at distances from far distance to near.

(F5) A lens comprising: an optical axis; at least two optical surfaces; an aberration profile having a focal distance and/or at least one power profile, wherein the aberration profile and/or at least one power profile configure the lens to provide an image profile and the

image profile in use with an eye is capable of stabilising and/or altering the growth of the eye; and wherein the lens is configured to provide visual performance at intermediate and far visual distances that is substantially equivalent to or better than a correctly prescribed single-vision lens for far visual distance and produces minimal ghosting at distances from far distance to near; wherein the image profile generates one or more of the following: myopic and/or hyperopic defocus at centre and/or periphery of the retina; a RIQ of at least 0.3, 0.35 or 0.4 at the retina and a slope of through-focus RIQ that degrades in the direction of eye growth; and a RIQ of at least 0.3, 0.35 or 0.4 at the retina and a slope of through-focus RIQ that improves in the direction of eye growth.

(F6) The lens of one or more F examples, wherein the image profile created by the lens has the affect of slowing the growth of the myopic eye by one or more stop signals.

(F7) The lens of one or more F examples, wherein the slope of through-focus RIQ that degrades in the direction of eye growth is one or more of the following: substantial, partial, sufficient or combinations thereof,

(F8) The lens of one or more F examples, myopia control lens.

(F9) The lens of one or more F examples, wherein the improvement in the direction of growth is one or more of the following: substantial, partial, sufficient or combinations thereof.

(F10) The lens of one or more F examples, wherein the lens has an aperture size of 2 mm or greater; 2.5 mm or greater, 3 mm or greater, 3.5 mm or greater or 4 mm or greater.

(F11) The lens of one or more F examples, wherein the lens is a multifocal lens with at least 1 Dioptre, at least 1.25 Dioptre, or at least 1.5 Dioptre of power variation across a central and/or a mid-peripheral portion of the optical zone of the lens.

(F12) The lens of one or more F examples, wherein the lens is a presbyopic multifocal lens with at least 1 Dioptre, at least 1.25 Dioptre or at least 1 Dioptre of power variation across a central and/or a mid-peripheral portion of the optical zone of the lens.

(F13) The lens of one or more F examples, wherein the lens is non-monotonic and non-periodic.

(F14) The lens of one or more F examples, wherein the lens is a non-pinhole lens.

(F15) The lens of one or more F examples, wherein the lens is a non-pinhole lens and the lens is a multifocal lens with at least 1, 1.25 or 1.5 Dioptre of power variation across a central and/or a mid-peripheral portion of the optical zone of the lens.

(F16) The lens of one or more F examples, wherein in the lens produces a retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth, where the RIQ is determined by a Visual Strehl Ratio that is measured substantially along the optical axis

when the aberration profile is tested on a model eye with no or substantially no aberrations and having an on-axis length equal or substantially equal to the focal distance.

(F17) The lens of one or more F examples, wherein in the lens produces a retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth, where the RIQ is determined by a Visual Strehl Ratio that is measured along the optical axis when the aberration profile is tested on a model eye with no aberrations and having an on-axis length equal to the focal distance.

(F18) The lens of one or more F examples, wherein the lens has at least one wavefront aberration profile associated with the optical axis, and the aberration profile is comprised of: at least two spherical aberration selected at least in part from a group comprising Zernike coefficients C(4,0) to C(20,0).

(F19) The lens of one or more F examples, wherein the lens can be characterised upon testing by at least the following properties: two or more higher order aberrations having one or more of the following components: a primary spherical aberration C(4,0), a secondary spherical aberration (C(6,0), a tertiary spherical aberration C(8,0), a quaternary spherical aberration C(10,0), a pentanary spherical aberration C(12,0), a hexanary spherical aberration C(14,0), a heptanary spherical aberration C(16,0), an octanary spherical aberration C(18,0) and a nanonary spherical aberration C(20,0).

(F20) The lens of one or more F examples, wherein the lens does not substantially reduce the amount of light passing through the lens.

(F21) The lens of one or more F examples, wherein the amount of light passing through the lens is at least 80%, 85%, 90%, 95% or 99%.

Examples set G:

(G1) A multifocal lens comprising: an optical axis; the multifocal lens is configured based on an aberration profile associated with the optical axis; the aberration profile is comprised of at least two spherical aberration terms and a defocus term; the multifocal lens is configured such that the visual performance of the multifocal lens at intermediate and far visual distances is substantially equivalent to, or better than, an appropriately or properly prescribed single-vision lens for far visual distance; and when tested with a defined visual rating scale of 1 to 10 units, the visual performance at the near visual distance is within two

units of the visual performance of the appropriately prescribed single-vision lens at far distance.

(G2) A multifocal lens comprising: an optical axis; the multifocal lens is configured in part on an aberration profile associated with the optical axis; the aberration profile is comprised of at least two spherical aberration terms and a defocus term; wherein the multifocal lens is configured such that the visual performance of the multifocal lens at intermediate and far visual distances is equivalent to or better than, an appropriately or correctly prescribed single-vision lens for far visual distance; and wherein upon testing with a defined visual rating scale of 1 to 10 units, the visual performance at the near visual distance is within two units of the visual performance of the correctly prescribed single-vision lens at far distance.

(G3) A multifocal lens comprising: an optical axis; the multifocal lens is configured based on an aberration profile associated with the optical axis; the aberration profile is comprised of at least two spherical aberration terms and a defocus term; and wherein upon testing with a defined overall visual rating scale of 1 to 10 units, the multifocal lens is configured such that the overall visual performance of the multifocal lens is substantially equivalent to or better than an appropriately prescribed single-vision lens for far visual distance.

(G4) A multifocal lens comprising: an optical axis; the multifocal lens is configured based in part on an aberration profile associated with the optical axis; the aberration profile is comprised of at least two spherical aberration terms and a defocus term; and wherein the multifocal lens is configured such that the visual performance on a visual analogue scale of the multifocal lens at far visual distance has a score of 9 or above in 55%, 60%, 65%, 70%, 75% or 80% of a representative sample of presbyopes; wherein the multifocal lens is configured such that the visual performance on a visual analogue scale of the multifocal lens at intermediate visual distance has a score of 9 or above in 45%, 50%, 55%, 60%, 65%, 70% or 75% of a representative sample of presbyopes; and wherein the multifocal lens is configured such that the visual performance on a visual analogue scale of the multifocal lens at near visual distance has a score of 9 or above in 25%, 30%, 35%, 40%, 45%, 50% or 55% of a representative sample of presbyopes.

(G5) A multifocal lens comprising: an optical axis; the multifocal lens being characterised or configured in part on an aberration profile associated with the optical axis; the aberration profile is comprised of at least two spherical aberration terms and a defocus term; and wherein the multifocal lens is configured such that the overall visual performance on a

visual analogue scale results in a score of 9 or above in 18%, 25%, 30%, 35%, 40% or 45% of a representative sample of presbyopes.

(G6) The multifocal lens of one or more G examples, wherein the multifocal lens in use provides substantially minimal ghosting to the vision of the user at near and far visual distances.

(G7) The multifocal lens of one or more G examples, wherein the substantially equivalent to or better visual performance is determined at least in part by a visual rating scale of 1 to 10 units.

(G8) The multifocal lens of one or more G examples, wherein the average visual performance of the lens in use for a representative sample of the affected population has a distance vision score of at least 8.5, has an intermediate vision score of at least 8.5 and has a near vision score of at least 7.5.

(G9) The multifocal lens of one or more G examples, wherein the average visual performance of the lens in use for a representative sample of the affected population has a distance vision score of at least 8.0, at least 8.2 or at least 8.4; has an intermediate vision score of at least 8.0, at least 8.2 or at least 8.4; has a near vision score of at least 7.0, at least 7.2 or at least 7.4; or combinations thereof.

(G10) The multifocal lens of one or more G examples, wherein the multifocal lens provides substantially minimal ghosting for a representative sample of the affected population at near and/or intermediate visual distances.

(G11) The multifocal lens of one or more G examples, wherein substantial minimal ghosting is an average visual performance score of less than or equal to 2.4, 2.2, 2, 1.8, 1.6 or 1.4 on the vision analogue ghosting scale of 1 to 10 units for a representative sample of the affected population using the multifocal lens.

(G12) The multifocal lens of one or more G example, wherein substantial minimal ghosting is a score of less than or equal to 2.4, 2.2, 2, 1.8, 1.6 or 1.4 on the vision rating ghosting scale 1 to 10 units utilising the average visual performance of the lens in use on a sample of people needing vision correction and/or therapy, for one or more of the following: myopia, hyperopia, astigmatism, emmetropia and presbyopia.

(G13) The multifocal lens of one or more G examples, wherein the lens provides myopia control therapy with minimal ghosting with or without vision correction.

(G14) The multifocal lens of one or more G examples, wherein the lens provides presbyopia correction with minimal ghosting with or without far vision correction.

(G15) The multifocal lens of one or more G examples, wherein the lens corrects astigmatism up to 1 Dioptre without substantial use of rotationally stable toric lens design features.

(G16) The multifocal lens of one or more G examples, wherein the lens corrects astigmatism up to 1 Dioptre without substantial use of rotationally stable toric lens design features with minimal ghosting.

(G17) The multifocal lens of one or more G examples, further comprising a first lens and a second lens wherein the first lens is biased to substantially optimise distance vision and the second lens is biased to substantially optimise near vision, and when used together provide monocular and binocular vision substantially equivalent to, or better than, an appropriately prescribed single-vision lens for far visual distance, wherein the pair of lenses provide stereopsis with minimal ghosting.

(G18) The multifocal lens of one or more G examples, wherein the average overall visual performance of the lens in use for a representative sample of the affected population has a overall vision score of at least 7.8, 8, 8.2, 8.4, 8.6, 8.8 or 9.

(G19) The multifocal lens of one or more G examples, wherein the average overall visual performance of the lens in use for a representative sample of the affected population has a overall vision score of at least 7.8, 8, 8.2, 8.4, 8.6, 8.8 or 9.

(G20) The multifocal lens of one or more G examples, wherein the multifocal lens in use provides substantially minimal ghosting to the vision of the user at near and far visual distances.

(G21) The multifocal lens of one or more G examples, wherein the substantially equivalent to or better visual performance is determined at least in part by a visual rating scale of 1 to 10 units.

(G22) The multifocal lens of one or more G examples, wherein the substantially equivalent to or better visual performance is substantially determined by a visual rating scale of 1 to 10 units.

(G23) The multifocal lens of one or more G examples, wherein the average visual performance of the lens in use for a representative sample of the affected population has a distance vision score of at least 8.5, has an intermediate vision score of at least 8.5 and has a near vision score of at least 7.5.

(G24) The multifocal lens of one or more G examples, wherein the average visual performance of the lens in use for a representative sample of the affected population has a distance vision score of at least 8.0, at least 8.2 or at least 8.4; has an intermediate vision score of at

least 8.0, at least 8.2 or at least 8.4; has a near vision score of at least 7.0, at least 7.2 or at least 7.4, or combinations thereof..

(G25) The multifocal lens of one or more G examples, wherein the multifocal lens in use provides the average visual performance of the lens in use for a representative sample of the affected population provide substantially minimal ghosting to the vision of the user at near and/or intermediate visual distances.

(G26) The multifocal lens of one or more G examples, wherein substantial minimal ghosting is defined as a score of less than or equal to 2.5, 2.2, 2, 1.8, 1.6 or 1.4 on the vision rating ghosting scale 1 to 10 units utilising the average visual performance of the lens in use for a representative sample of the affected population.

(G27) The multifocal lens of one or more G examples, wherein the average overall visual performance of the lens in use for a representative sample of the affected population has a overall vision score of at least 7.8, 8, 8.2, 8.4, 8.6, 8.8 or 9.

(G28) The multifocal lens of one or more G examples, wherein the single-vision lens is a lens with a substantially constant power across a substantial portion of an optic zone of the single-vision lens.

(G29) The multifocal lens of one or more G examples, wherein the lens is used for a presbyopic eye.

(G30) The multifocal lens of one or more G examples, wherein the lens is further characterised by minimal, or no, ghosting at near, intermediate and far distances.

(G31) The multifocal lens of one or more G examples, where in the substantially continuous distances is continuous.

(G32) The multifocal lens of one or more G examples, wherein the single-vision lens is one or more of the following: prescribed, appropriately prescribed, correctly prescribed and effectively prescribed.

(G33) The multifocal lens of one or more G examples, wherein the single-vision lens is a lens with a substantially constant power across a substantial portion of an optic zone of the single-vision lens.

(G34) The multifocal lens of one or more G examples, wherein the single-vision lens is a lens with a constant power across a portion of an optic zone of the single-vision lens.

(G35) The multifocal lens of one or more G examples, wherein the single-vision lens is a lens with a substantially constant power across a portion of one or more optic zones of the single-vision lens.

(G36) The multifocal lens of one or more G examples, wherein the multifocal lens is used for a presbyopic eye.

(G37) The multifocal lens of one or more G examples, wherein the lens is configured for a presbyopic eye.

(G38) The multifocal lens of one or more G examples, wherein the lens is configured to optically correct or substantially correct presbyopia.

(G39) The multifocal lens of one or more G examples, wherein the lens is configured to mitigate or substantially mitigate the optical consequences of presbyopia.

(G40) The multifocal lens of one or more G examples, wherein the lens is configured to alter or substantially alter a presbyopic condition to a non-presbyopic condition.

(G41) The multifocal lens of one or more G examples, wherein the multifocal lens is used for at least correcting a presbyopic eye condition and when used provides an appropriate correction to adjust the vision of the user towards substantially normal non-presbyopic vision.

(G42) The multifocal lens of one or more G examples, wherein normal vision is 6/6 or better.

(G43) The multifocal lens of one or more G examples, wherein the multifocal lens is further characterised by minimal, substantially no or no, ghosting at near, intermediate and far distances.

(G44) The multifocal lens of one or more G examples, wherein the multifocal lens is further characterised by minimal, substantially no or no, ghosting at near distances, intermediate distances and far distances.

(G45) The multifocal lens of one or more G examples, wherein the multifocal lens is further configured to provide minimal, substantially no or no, ghosting at near, intermediate and far distances.

(G46) The multifocal lens of one or more G examples, wherein the minimal ghosting is a lack of an undesired secondary image appearing at the image plane of the optical system.

(G47) The multifocal lens of one or more G examples, wherein the minimal ghosting is a lack of an undesired secondary image appearing on the retina of the eye.

(G48) The multifocal lens of one or more G examples, wherein the minimal ghosting is a lack of an undesired double image appearing on the retina of the eye.

(G49) The multifocal lens of one or more G examples, wherein the minimal ghosting is a lack of false out-of-focus image appearing along side of the primary image in an optical system.

(G50) The multifocal lens of one or more G examples, wherein the multifocal lens is further configured to provide a sufficient lack of ghosting in a portion of near, intermediate and far distances.

(G51) The multifocal lens of one or more G examples, wherein the multifocal lens is further configured to provide a sufficient lack of ghosting at near distances, intermediate distances and far distances.

(G52) The multifocal lens of one or more G examples, wherein the multifocal lens is further configured to provide a sufficient lack of ghosting in a portion of two or more of the following: near, intermediate and far distances.

(G53) The multifocal lens of one or more G examples, wherein lack of ghosting is lack of undesired image appearing at the image plane of the optical system.

(G54) The multifocal lens of one or more G examples, wherein lack of ghosting is a lack of false out of focus images appearing along side of the primary image in an optical system.

(G55) The multifocal lens of one or more G examples, wherein the multifocal lens is further configured to provide a sufficient lack of ghosting in a portion of two or more of the following: near distances, intermediate distances and far distances.

(G56) The multifocal lens of one or more G examples, wherein the multifocal lens is further configured to provide the RIQ of at least 0.1, 0.13, 0.17, 0.2, 0.225, or 0.25 in the near distance range, the RIQ of at least 0.27, 0.3, 0.33, 0.35, 0.37 or 0.4 in the intermediate distance range and the RIQ of at least 0.35, 0.37, 0.4, 0.42, 0.45, 0.47, or 0.5 in the far distance range.

(G57) The multifocal lens of one or more G examples, wherein the multifocal lens is further configured to provide two or more of the following: the RIQ of at least 0.1, 0.13, 0.17, 0.2, 0.225, or 0.25 in the near distance range, the RIQ of at least 0.27, 0.3, 0.33, 0.35, 0.37 or 0.4 in the intermediate distance range and the RIQ of at least 0.35, 0.37, 0.4, 0.42, 0.45, 0.47, or 0.5 in the far distance range.

(G58) The multifocal lens of one or more G examples, wherein the RIQs are selected in the near, intermediate and far distance ranges such that the multifocal lens is configured to provide minimal, or no, ghosting in near, intermediate and far distances.

(G59) The multifocal lens of one or more G examples, wherein the multifocal lens is configured to substantially eliminate, or substantially reduce, ghosting at near, intermediate and far distances.

(G60) The multifocal lens of one or more G examples, wherein the multifocal lens is configured to substantially eliminate, or substantially reduce, ghosting at near distances, intermediate distances and far distances.

(G61) The multifocal lens of one or more G examples, wherein near distance is the range of 33 cm to 50 cm or 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm, 50 cm to 80 cm or 50 cm to 70 cm; and far distance is the range of 100 cm or greater, 80 cm or greater or 70 cm or greater.

(G62) The multifocal lens of one or more G examples, wherein near distance is the range of 33 cm to 50 cm or 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm, 50 cm to 80 cm or 50 cm to 70 cm; and far distance is the range of 100 cm or greater, 80 cm or greater or 70 cm or greater and the near, intermediate and far distances are determined by the distance from the object being focused on.

(G63) The multifocal lens of one or more G examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm or greater.

(G64) The multifocal lens of one or more G examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm or greater and the near, intermediate and far distances are determined by the distance from the object being focused on.

(G65) The multifocal lens of one or more G examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm to optical infinity.

(G66) The multifocal lens of one or more G examples, wherein near distance is the range of 40 cm to 50 cm; intermediate distance is the range of 50 cm to 100 cm; and far distance is the range of 100 cm to optical infinity and the near, intermediate and far distances are determined by the distance from the object being focused on.

(G67) The multifocal lens of one or more G examples, wherein the multifocal lens is configured to minimize, or reduce, ghosting at near, intermediate and far distances when used on an eye.

(G68) The multifocal lens of one or more G examples, wherein the multifocal lens is configured to minimize, or reduce, ghosting at near distances, intermediate distances and far distances when used on an eye.

(G69) The multifocal lens of one or more G examples, wherein the range of substantially continuous distances is continuous.

(G70) The multifocal lens of one or more G examples, wherein the range of substantially continuous distances is continuous and goes from 40 cm to optical infinity.

(G71) The multifocal lens of one or more G examples, wherein the range of substantially continuous distances is from 33 cm to optical infinity.

(G72) The multifocal lens of one or more G examples, wherein the lens is configured such that at least 40%, 50%, 60% or 70% of a randomly selected group of 15 affected individuals in the near distances, intermediate distances and far distances perceive minimal, or no, ghosting at near distances, intermediate distances and far distances.

(G73) The multifocal lens of one or more G examples, wherein the lens is configured such that at least 60%, 70%, 80% or 90% of a randomly selected group of 15 affected individuals in the intermediate distances and far distances perceive minimal, or no, ghosting at intermediate distances and far distances.

(G74) The multifocal lens of one or more G examples, wherein the single vision lens provides a visual acuity for the user of one or more of the following: at least 20/20, at least 20/30, at least 20/40, at least about 20/20, at least about 20/30 and at least about 20/40, at far visual distances.

(G75) The multifocal lens of one or more G examples, wherein the aberration profile is comprised of a defocus term and at least two, two or more, three, three or more, four, four or more, five, five or more, six, six or more, seven, seven or more, eight, eight or more, nine, nine or more, ten, or ten or more spherical aberration terms.

(G76) The multifocal lens of one or more G examples, wherein the aberration profile is comprised of a defocus term and at least two, three, four, five, six, seven, eight, nine, or at least ten spherical aberration terms.

(G77) The multifocal lens of one or more G examples, wherein the aberration profile is comprised of a defocus term and spherical aberration terms between C(4,0) and C(6,0), C(4,0) and C(8,0), C(4,0) and C(10,0), C(4,0) and C(12,0), C(4,0) and C(14,0), C(4,0) and C(16,0), C(4,0) and C(18,0), or C(4,0) and C(20,0).

(G78) The multifocal lens of one or more G examples, wherein the single vision lens provides a visual acuity that is the best-corrected visual acuity.

(G79) The multifocal lens of one or more G examples, wherein the best-corrected visual acuity is a visual acuity that cannot be substantially improved by further manipulating the power of the single vision lens.

(G80) The multifocal lens of one or more G examples, wherein the lens has two optical surfaces.

(G81) The multifocal lens of one or more G examples, wherein the least one aberration profile is along the optical axis of the lens.

(G82) The multifocal lens of one or more G examples, wherein the lens has a focal distance.

(G83) The multifocal lens of one or more G examples, wherein the aberration profile includes higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0).

(G84) The multifocal lens of one or more G examples, wherein the aberration profile provides, for a model eye with no, or substantially no, aberrations and an on-axis length equal to the focal distance: the retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth; and the RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(G85) The multifocal lens of one or more G examples, wherein the aberration profile provides, for a model eye with no, or substantially no, aberrations and an on-axis length equal to the focal distance: the retinal image quality (RIQ) with a through focus slope that improves in a direction of eye growth; and the RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(G86) The multifocal lens of one or more G examples, wherein the lens has an optical axis and an aberration profile about its optical axis, the aberration profile: having a focal distance; and including higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), wherein the aberration profile provides, for a model eye with no, or substantially no, aberrations and an on-axis length equal, or substantially equal, to the focal distance: the RIQ with a through focus slope that degrades in a direction of eye growth; and the RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured along the optical axis for at least one pupil

diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(G87) The multifocal lens of one or more G examples, wherein the lens has an optical axis and an aberration profile about its optical axis, the aberration profile: having a focal distance; and including higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), wherein the aberration profile provides, for a model eye with no, or substantially no, aberrations and an on-axis length equal, or substantially equal, to the focal distance: the RIQ with a through focus slope that improves in a direction of eye growth; and the RIQ of at least 0.3; wherein the RIQ is Visual Strehl Ratio measured along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

(G88) The multifocal lens of one or more G examples, wherein the focal distance is a prescription focal distance for a myopic, hyperopic, astigmatic, and/or presbyopic eye and wherein the focal distance differs from the focal distance for a C(2,0) Zernike coefficient of the aberration profile.

(G89) The multifocal lens of one or more G examples, wherein the higher order aberrations include at least two spherical aberration terms selected from the group C(4,0) to C(20,0).

(G90) The multifocal lens of one or more G examples, wherein the higher order aberrations include at least three spherical aberration terms selected from the group C(4,0) to C(20,0).

(G91) The multifocal lens of one or more G examples, wherein the higher order aberrations include at least five spherical aberration terms selected from the group C(4,0) to C(20,0).

(G92) The multifocal lens of one or more G examples, wherein the average slope over a horizontal field of at least -20° to +20° degrades in a direction of eye growth.

(G93) The multifocal lens of one or more G examples, wherein the average slope over a horizontal field of at least -20° to +20° improves in a direction of eye growth.

(G94) The multifocal lens of one or more G examples, wherein the average slope over a vertical field of at least -20° to +20° degrades in a direction of eye growth.

(G95) The multifocal lens of one or more G examples, wherein the average slope over a vertical field of at least -20° to +20° improves in a direction of eye growth.

(G96) The multifocal lens of one or more G examples, wherein the slope for a substantial portion of the field angles over a horizontal field of at least -20° to +20° degrades in a direction of eye growth.

(G97) The multifocal lens of one or more G examples, wherein the substantial portion of the field angles over a horizontal field is at least 75%, 85%, 95% or 99% of the field angles.

(G98) The multifocal lens of one or more G examples, wherein the substantial portion of the field angles over a horizontal field is every field angle.

(G99) The multifocal lens of one or more G examples, wherein the slope for a substantial portion of the field angles over a vertical field of at least -20° to +20° degrades in a direction of eye growth.

(G100) The multifocal lens of one or more G examples, wherein the substantial portion of the field angles over a vertical field is every angle.

(G101) The multifocal lens of one or more G examples, wherein the substantial portion of the field angles over a vertical field is at least 75%, 85%, 95% or 99% of the field angles.

(G102) The multifocal lens of one or more G examples, wherein the aberration profile provides the RIQ of at least 0.3 at the focal length for a substantial portion of pupil diameters in the range 3 mm to 6 mm.

(G103) The multifocal lens of one or more G examples, wherein the aberration profile provides the RIQ of at least 0.3 at the focal length for a substantial portion of pupil diameters in the range 4 mm to 5 mm.

(G104) The multifocal lens of one or more G examples, wherein the aberration profile provides the RIQ with a through focus slope that degrades in a direction of eye growth when primary or secondary astigmatism is added to the aberration profile.

(G105) The multifocal lens of one or more G examples, wherein the aberration profile provides the RIQ with a through focus slope that improves in a direction of eye growth when primary or secondary astigmatism is added to the aberration profile.

(G106) The multifocal lens of one or more G examples, wherein the primary or secondary astigmatism is added to the desired aberration profile by altering one or more of the following terms: C(2,-2), C(2,2), C(4,-2), C(4,2), C(6,-2), and/or C(6,2).

(G107) The multifocal lens of one or more G examples, wherein the aberration profile provides the RIQ with a through focus slope that degrades in a direction of eye growth when secondary astigmatism is added to the aberration profile.

(G108) The multifocal lens of one or more G examples, wherein the secondary astigmatism is added to the desired aberration profile by altering one or more of the following terms: C(2,-2), C(2,2), C(4,-2), C(4,2), C(6,-2), and/or C(6,2).

(G109) The multifocal lens of one or more G examples, wherein the RIQ is characterised by

$$RIQ = \frac{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}|^2))))}{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}|^2))))},$$

wherein:

Fmin is 0 cycles/degree and *Fmax* is 30 cycles/degree;

CSF(x, y) denotes the contrast sensitivity function

$CSF(F)=2.6(0.0192+0.114f)e^{-(0.114f)^{1.1}}$,

where *f* specifies the tested spatial frequency, in the range of F_{min} to F_{max};

FT denotes a 2D fast Fourier transform;

A(ρ,θ) denotes the pupil diameter;

W(ρ,θ) denotes wavefront phase of the test case measured for i=1 to 20

$$W(\rho,\theta) = \sum_{i=1}^{k} a_i Z_i(\rho,\theta);$$

Wdiff(ρ, θ) denotes wavefront phase of the diffraction limited case;

ρ and *θ* are normalised polar coordinates, where ρ represents the radial coordinate and θ represents the angular coordinate or azimuth; and

λ denotes wavelength.

(G110) The multifocal lens of one or more G examples, wherein the multifocal lens includes an optical axis and an aberration profile along the optical axis that provides: a focal distance for a C(2,0) Zernike coefficient term; a peak Visual Strehl Ratio ('first Visual Strehl Ratio') within a through focus range, and a Visual Strehl Ratio that remains at or above a second Visual Strehl Ratio over the through focus range that includes said focal distance, wherein the Visual Strehl Ratio is measured for a model eye with no, or substantially no, aberration and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a

wavelength selected from within the range 540 nm to 590 nm inclusive, and wherein the first Visual Strehl Ratio is at least 0.35, the second Visual Strehl Ratio is at least 0.1 and the through focus range is at least 1.8 Dioptres.

(G111) The multifocal lens of one or more G examples, wherein the multifocal lens includes an optical axis and an aberration profile along the optical axis that provides: a focal distance for a C(2,0) Zernike coefficient term; a peak Visual Strehl Ratio ('first Visual Strehl Ratio') within a through focus range, and a Visual Strehl Ratio that remains at or above a second Visual Strehl Ratio over the through focus range that includes said focal distance, wherein the Visual Strehl Ratio is measured for a model eye with no aberration and is measured along the optical axis for at least one pupil diameter in the range 3 mm to 5 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive, at a wavelength selected from within the range 540 nm to 590 nm inclusive, and wherein the first Visual Strehl Ratio is at least 0.35, the second Visual Strehl Ratio is at least 0.1 and the through focus range is at least 1.8 Dioptres.

(G112) The multifocal lens of one or more G examples, wherein the first Visual Strehl Ratio is at least 0.3, 0.35, 0.4, 0.5, 0.6, 0.7 or 0.8.

(G113) The multifocal lens of one or more G examples, wherein the second Visual Strehl Ratio is at least 0.1, 0.12, 0.15, 0.18 or 0.2.

(G114) The multifocal lens of one or more G examples, wherein the through focus range is at least 1.7, 1.8, 1.9, 2, 2.1, 2.25 or 2.5 Dioptres.

(G115) The multifocal lens of one or more G examples, wherein the lens has a prescription focal distance located within 0.75, 0.5, 0.3, or 0.25 Dioptres, inclusive, of an end of the through focus range.

(G116) The multifocal lens of one or more G examples, wherein the end of the through focus range is the negative power end.

(G117) The multifocal lens of one or more G examples, wherein the end of the through focus range is the positive power end.

(G118) The multifocal lens of one or more G examples, wherein the Visual Strehl Ratio remains at or above the second Visual Strehl Ratio over the through focus range and over a range of pupil diameters of at least 1 mm, 1.5 mm, 2 mm, 2.5 mm, or 3 mm.

(G119) The multifocal lens of one or more G examples, wherein the combination of higher order aberrations includes at least one of primary spherical aberration and secondary spherical aberration.

(G120) The multifocal lens of one or more G examples, wherein the higher order aberrations include at least two, three, or five spherical aberration terms selected from the group C(4,0) to C(20,0).

(G121) The multifocal lens of one or more G examples, wherein the aberration profile can be substantially characterised using spherical aberration Zernike coefficients C(4,0) to C(20,0).

(G122) The multifocal lens of one or more G examples, wherein the RIQ for a substantial portion of the angles over a horizontal field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.4.

(G123) The multifocal lens of one or more G examples, wherein the RIQ for a substantial portion of the angles over a horizontal field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.35.

(G124) The multifocal lens of one or more G examples, wherein the RIQ for a substantial portion of the angles over a horizontal field of at least -10° to +10°, -20° to +20° or -30° to +30° is at least 0.3.

(G125) The multifocal lens of one or more G examples, wherein the lens is one or more of the following: contact lens, corneal onlays, corneal inlays, anterior chamber intraocular lens or posterior chamber intraocular lens.

(G126) The multifocal lens of one or more G examples, wherein the lens is one of the following: contact lens, corneal onlays, corneal inlays, anterior chamber intraocular lens or posterior chamber intraocular lens.

(G127) The multifocal lens of one or more G examples, wherein a first multifocal lens is provided based on one or more of the G examples and a second multifocal lens is provided based on one or more of the G examples to form a pair of lenses.

(G128) The multifocal lens of one or more G examples, wherein the first multifocal lens is provided based on one or more of the G examples and a second lens is provided to form a pair of lenses.

(G129) The multifocal lens of one or more G examples, wherein a pair of multifocal lenses are provided for use by an individual to substantially correct the individual's vision.

(G130) The lens of one or more G examples, wherein the lens does not substantially reduce the amount of light passing through the lens.

(G131) The lens of one or more G examples, wherein the amount of light passing through the lens is at least 80%, 85%, 90%, 95% or 99%.

(G132) A method for making or using one or more of the multifocal lenses of one or more G examples.

Example set H:

(H1) A system of lenses comprising: a series of lenses, wherein the lenses in the series of lenses have the following properties: at least two spherical aberration terms selected at least in part from a group comprising spherical aberration coefficients from C(4,0) to C(20,0), that provides correction of astigmatism up to 1 Dioptre without substantial use of rotationally stable toric lens design features; and wherein the lenses in the series of lenses eliminate the need for maintaining additional inventory for astigmatic corrections relating to cylinder powers of 0.5, 0.75 and 1D, resulting in a reduction of stock keeping units by at least six, eight, twelve, sixteen, eighteen, thirty six, fifty-four or 108 times for each sphere power.

Example set J:

(J1) A multifocal lens for an eye comprising: at least one optical axis; at least one wavefront aberration profile associated with the optical axis and the prescription focal power of the lens; wherein, the multifocal lens is configured to expand the depth-of-focus of the eye by altering the retinal image quality over a range of distances via manipulation of the at least one wavefront aberration profile for the eye.

(J2) A multifocal lens for an eye comprising: at least one optical axis; at least one wavefront aberration profile associated with the optical axis and the aberration profile is comprised of at least two spherical aberration terms and the prescription focal power of the lens; wherein the lens is configured such that the lens expands the depth-of-focus of the eye by altering the retinal image quality over a range of distances via manipulation of at least one wavefront aberration profile for the eye.

(J3) A multifocal lens for an eye comprising: at least one optical axis; at least one wavefront aberration profile associated with the optical axis, and the aberration profile is comprised of: at least two spherical aberration selected at least in part from a group comprising Zernike coefficients C(4,0) to C(20,0), and a prescription focal power of the lens that may be provided at least in part by C(2,0) Zernike coefficient term either with, or without, one or more prescription offset terms; wherein, the multifocal lens is configured to expand the

depth-of-focus of the eye by improving the retinal image quality over a range of distances via manipulation of the at least one wavefront aberration profile.

(J4) The lens of one or more J examples, wherein the lens does not substantially reduce the amount of light passing through the lens.

(J5) The lens of one or more J examples, wherein the amount of light passing through the lens is at least 80%, 85%, 90%, 95% or 99%.

Example set K:

(K1) A lens comprising: an optical axis; at least two surfaces; wherein the lens has at least one power profile, the power profile is characterised upon testing by a function that is non-monotonic over a substantial portion of the half-chord optical zone of the lens.

(K2) A lens comprising: an optical axis; at least two surfaces; wherein the lens has at least one power profile, the power profile is characterised by a function that is non-monotonic over a substantial portion of the half-chord optical zone of the lens.

(K3) A lens comprising: an optical axis; at least two surfaces; wherein the lens has at least one power profile, the power profile is characterised by a function that is aperiodic over a substantial portion of the half-chord optical zone of the lens.

(K4) A lens comprising: an optical axis; at least two surfaces; wherein the lens has at least one power profile, the power profile is characterised upon testing by a function that is aperiodic over a substantial portion of the half-chord optical zone of the lens.

(K5) A lens comprising: an optical axis; at least two surfaces; wherein the lens has at least one power profile, the power profile is characterised by a function that is aperiodic and non-monotonic over a substantial portion of the half-chord optical zone of the lens.

(K6) A lens comprising: an optical axis; at least two surfaces; wherein the lens has at least one power profile, the power profile is characterised upon testing by a function that is aperiodic and non-monotonic over a substantial portion of the half-chord optical zone of the lens.

(K7) A lens comprising: an optical axis; at least two surfaces; wherein the lens has at least one power profile, the power profile is configured such that the power profile is non-monotonic over a substantial portion of the half-chord optical zone of the lens.

(K8) A lens comprising: an optical axis; at least two surfaces; wherein the lens has at least one power profile, the power profile is configured such that the power profile is aperiodic over a substantial portion of the half-chord optical zone of the lens.

(K9) A lens comprising: an optical axis; at least two surfaces; wherein the lens has at least one power profile, the power profile is configured such that the power profile is aperiodic and non-monotonic over a substantial portion of the half-chord optical zone of the lens.

(K10) A lens comprising: an optical axis; at least two surfaces; and wherein the lens has at least one power profile, the power profile is configured such that the absolute of a first derivative of the power profile has at least 5 peaks whose absolute amplitude is greater than 0.025 with units of 1D per 0.01 mm along its half-chord.

(K11) A lens comprising: an optical axis; at least two surfaces; and wherein the lens has at least one power profile, the power profile is characterised such that the absolute of a first derivative of the power profile has at least 5 peaks whose absolute amplitude is greater than 0.025 with units of 1D per 0.01 mm along its half-chord.

(K12) The multifocal lens comprising: an optical axis; at least two surfaces; and wherein the multifocal lens has a power profile such that an absolute of a first derivative of the power profile, as a function of half-chord diameter, has at least 5 peaks whose absolute amplitude is greater than 0.025 with units of 1D per 0.01 mm along its half-chord diameter.

(K13) The lens of one or more of K examples, wherein the lens is configured at least in part on an aberration profile associated with the optical axis.

(K14) The lens of one or more of K examples, wherein the lens has an aberration profile comprised of a defocus term and at least two spherical aberration terms.

(K15) The lens of one or more of K examples, wherein the lens is a multifocal or bifocal.K15 The lens of one or more of K examples, wherein the substantial portion of the half-chord is 50%, 60%, 70%, 80%, 90% or 95% of the half-chord.

(K16) A method of characterising lens power profile comprising the steps of: measuring the spatially resolved power profile; computing a first derivative of the power profile; and analysing or describing the power profile as a first derivative of the power profile.

(K17) The method of one or more of K examples, wherein the first of derivative of the power profile is an absolute of the first derivative of the power profile.

(K18) A method of characterising lens power profile comprising the steps of: measuring the power profile; computing a Fourier transform of the power profile; and describing the power profile as a Fourier spectrum, wherein a normalised absolute amplitude of the Fourier transform of the power profile is greater than 0.2 at one or more spatial frequencies at or above 1.25 cycles per millimetre.

(K19) The method of one more K examples, wherein the Fourier spectrum of the power profile

is the amplitude of the Fourier spectrum.

(K20) The method of one more K examples, wherein the Fourier spectrum of the power profile is the phase of the Fourier spectrum.

(K21) The method of one more K examples, wherein the Fourier spectrum is an absolute of the Fourier spectrum.

(K22) The method of one more K examples, wherein the Fourier spectrum is a real of the Fourier spectrum.

(K23) The method of one more K examples, wherein the Fourier spectrum is a normalised absolute of the Fourier spectrum.

(K24) A lens comprising: an optical axis; at least two surfaces; wherein the lens has at least one power profile that is characterised by a normalised absolute amplitude of the Fourier transform of the power profile that is greater than 0.2 at one or more spatial frequencies at or above 1.25 cycles per millimetre.

(K25) The lens of one or more K examples, wherein the lens does not substantially reduce the amount of light passing through the lens.

(K26) The lens of one or more K examples, wherein the amount of light passing through the lens is at least 80%, 85%, 90%, 95% or 99%.

Example set L:

(L1) A multifocal lens comprising: an optical axis; an effective near addition power of at least 1D; an optic zone associated with the optical axis with an aberration profile; wherein the aberration profile is comprised of at least two spherical aberration terms; and the multifocal lens is configured to provide minimal ghosting along a range of visual distances, including near, intermediate and far distances.

(L2) The multifocal lens of one or more L examples, wherein minimal ghosting is an average rating of two or less for a group of at least 15 subjects on a 1 to 10 visual analogue scale.

(L3) The multifocal lens of one or more L examples, wherein minimal ghosting is an average rating of two or less for a group of at least 15 subjects on a 1 to 10 visual analogue scale, wherein the at least 15 subjects are selected from a representative population of individuals with one or more of the following conditions: myopia, hyperopia, astigmatism and presbyopia.

(L4) The multifocal lens of one or more L examples, wherein minimal ghosting is an average rating of two or less for a group of at least 15 subjects on a 1 to 10 visual analogue scale, wherein the at least 15 subjects are selected from a representative population of emmetropic non-presbyopes.

(L5) The multifocal lens of one or more L examples, wherein minimal ghosting is a score of less than or equal to 2.4, 2.2, 2, 1.8, 1.6 or 1.4 on the vision analogue rating scale 1 to 10 units utilising the average visual performance of the lens in use on a sample of people needing vision correction and/or therapy, for one or more of the following: myopia, hyperopia, astigmatism, emmetropia and presbyopia.

(L6) The multifocal lens of one or more L examples, wherein at least 30% of the individuals tested report no ghosting at near visual distances and far visual distances.

(L7) The multifocal lens of one or more L examples, wherein at least 30% of the individuals tested report no ghosting for visual distances along a range of substantially continuous visual distances, including near, intermediate and far distances.

(L8) The multifocal lens of one or more L examples, wherein at least 40% of the individuals tested report no ghosting at near visual distances and far visual distances.

(L9) The multifocal lens of one or more L examples, wherein at least 40% of the individuals tested report no ghosting at near, intermediate and far distances.

(L10) The multifocal lens of one or more L examples, wherein at least 40% of the individuals tested report a rating of less than two for ghosting at both near and far visual distances reported.

(L11) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens include an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus term and at least two spherical aberration terms; and an effective additional power of at least 1D; the multifocal lens is configured to provide: an average rating of at least 9 for distance vision on a visual analogue scale of 1 to 10; an average rating of at least 8.5 for intermediate vision on the visual analogue scale; an average rating of at least 7.5 for near vision on the visual analogue scale; an average rating of less than 2 for ghosting for far vision on the visual analogue scale; an average rating of less than 2 for ghosting for near vision on the visual analogue scale; and when tested on a sample of at least 15 participants who are correctable to at least 6/6 or better in both eyes and have an astigmatism of less than 1.5D and who are selected from an affected population.

(L12) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens include an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus term and at least two spherical aberration terms; and an effective additional power of at least 1D; the multifocal lens is configured to provide: at least 60% of the individuals tested for far visual distances report a score of greater than 9 on a visual analogue scale ranging between 1 and 10; at least 50% of the individuals tested for intermediate visual distances report a score of greater than 9 on the visual analogue scale; at least 30% of the individuals tested for near visual distances report a score of greater than 9 on the visual analogue scale; below 15% of the individuals tested for ghosting at distance report a score of less than 3 on the visual analogue scale; at least 40% of the individuals tested for ghosting at either distance or near report a score of less than 2 on the visual analogue scale; and at least 25% of the individuals tested report a score of greater than 9 on the visual analogue scale for cumulative vision encompassing distance, intermediate, near, lack of ghosting at distance, and lack of ghosting at near.

(L13) The multifocal lens of one or more L examples, wherein at least 30% of the individuals tested report a score of greater than 9 on the visual analogue scale for cumulative vision encompassing distance, intermediate, near, lack of ghosting at distance, and lack of ghosting at near.

(L14) The multifocal lens of one or more L examples, wherein at least 35% of the individuals tested report a score of greater than 9 on the visual analogue scale for cumulative vision encompassing distance, intermediate, near, lack of ghosting at distance, and lack of ghosting at near.

(L15) The multifocal lens of one or more L examples, wherein at least 40% of the individuals tested report a score of greater than 9 on the visual analogue scale for cumulative vision encompassing distance, intermediate, near, lack of ghosting at distance, and lack of ghosting at near.

(L16) The multifocal lens of one or more L examples, wherein at least 55% of the individuals tested for intermediate visual distances report a score of greater than 9 on a visual analogue scale ranging between 1 and 10.

(L17) The multifocal lens of one or more L examples, wherein at least 35% of the individuals tested for near visual distances report a score of greater than 9 on the visual analogue scale ranging between 1 and 10.

(L18) The multifocal lens of one or more L examples, wherein at least 40% of the individuals tested for near visual distances report a score of greater than 9 on the visual analogue scale ranging between 1 and 10.

(L19) The multifocal lens of one or more L examples, wherein at least 45% of the individuals tested for near visual distances report a score of greater than 9 on the visual analogue scale ranging between 1 and 10.

(L20) The multifocal lens of one or more L examples, wherein at least 30% of the individuals tested report a score of greater than 9 on the visual analogue scale for cumulative vision encompassing distance, intermediate, near, lack of ghosting at distance, and lack of ghosting at near.

(L21) The multifocal lens of one or more L examples, wherein at least 30% of the individuals tested report a score of greater than 9 on the visual analogue scale for cumulative vision encompassing distance, intermediate, near, lack of ghosting at distance, and lack of ghosting at near.

(L22) The multifocal lens of one or more L examples, wherein at least 35% of the individuals tested report a score of greater than 9 on the visual analogue scale for cumulative vision encompassing distance, intermediate, near, lack of ghosting at distance, and lack of ghosting at near.

(L23) The multifocal lens of one or more L examples, wherein at least 40% of the individuals tested report a score of greater than 9 on the visual analogue scale for cumulative vision encompassing distance, intermediate, near, lack of ghosting at distance, and lack of ghosting at near.

(L24) The multifocal lens of one or more L examples, wherein at least 45% of the individuals tested report a score of greater than 9 on the visual analogue scale for cumulative vision encompassing distance, intermediate, near, lack of ghosting at distance, and lack of ghosting at near.

(L25) The multifocal lens of one or more L examples, wherein at least 45% of the individuals tested for ghosting at either distance or near report a score of less than 2 on the visual analogue scale.

(L26) The multifocal lens of one or more L examples, wherein at least 50% of the individuals tested for ghosting at either distance or near report a score of less than 2 on the visual analogue scale.

(L27) The multifocal lens of one or more L examples, wherein at least 55% of the individuals tested for ghosting at either distance or near report a score of less than 2 on the visual analogue scale.

(L28) The multifocal lens of one or more L examples, wherein at least 60% of the individuals tested for ghosting at either distance or near report a score of less than 2 on the visual analogue scale.

(L29) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens include an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus term and at least two spherical aberration terms; and an effective additional power of at least 1D; the multifocal lens is configured to provide: an average visual acuity for far visual distances of at least 0.00 on a LogMAR visual acuity chart; an average visual acuity for intermediate visual distances at least 0.00 on a LogMAR visual acuity chart; an average visual acuity for near visual distances at least 0.02 on a LogMAR visual acuity chart; an average rating of less than 2 for ghosting for far vision on the visual analogue scale; an average rating of less than 2 for ghosting for near vision on the visual analogue scale; and when tested on a sample of at least 15 participants who are correctable to at least 6/6 visual acuity or better in both eyes and have an astigmatism of less than 1.5D.

(L30) The multifocal lens of one or more L examples, wherein the multifocal lens has an effective additional power of at least 1.25D.

(L31) The multifocal lens of one or more L examples, wherein the multifocal lens has an effective additional power of at least 1.5D.

(L32) The lens of one or more L examples, wherein the lens does not substantially reduce the amount of light passing through the lens.

(L33) The lens of one or more L examples, wherein the amount of light passing through the lens is at least 80%, 85%, 90%, 95% or 99%.

(L34) The multifocal lens of one or more L examples, wherein the participants are selected from an affected population.

(L35) A multifocal lens comprising: an optical axis; the optical properties of the multifocal lens are configured or described based on an aberration profile associated with the optical axis; the aberration profile is comprised of a defocus term and at least two spherical aberration terms; and the multifocal lens is configured to provide: an average subjective visual rating of at least 9 for distance vision on a visual analogue scale; an average subjective visual

rating of at least 9 for intermediate vision on a visual analogue scale; an average subjective visual rating of at least 7.5 for near vision on a visual analogue scale; an average subjective visual rating of less than 2 for far vision on a ghosting analogue scale; and/or an average subjective visual rating of less than 2 for near vision on a ghosting analogue scale; when tested on a sample of at least 15 participants randomly selected from an affected population.

It will be understood that the inventions disclosed and defined in this specification extends to alternative combinations of two or more of the individual features mentioned or evident from the text or drawings. These different combinations constitute various alternative aspects of the embodiments disclosed.

Section 24: Appendix A – example combinations of spherical aberration

Combination	C (2,0)	C(4,0)	C(6,0)	C(8,0)	C(10,0)	C(12,0)	C(14,0)	C(16,0)	C(18,0)	C(20,0)
No Aberr	0	0	0	0	0	0	0	0	0	0
1	0	-0.125	-0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0	-0.100	-0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0	-0.100	-0.025	0.025	0.000	0.000	0.000	0.000	0.000	0.000
4	0	-0.100	0.025	0.075	0.025	0.025	0.025	0.025	0.025	0.000
5	0	-0.075	-0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0	-0.075	-0.025	0.050	0.000	-0.025	-0.025	0.000	0.025	0.000
7	0	-0.050	-0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0	-0.050	-0.050	0.050	0.025	0.000	0.000	0.000	0.000	0.000
9	0	-0.050	-0.025	0.050	0.000	-0.025	-0.025	0.000	0.025	0.025
10	0	-0.025	-0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0	-0.025	-0.025	0.050	0.025	-0.025	-0.025	0.000	0.025	0.025
12	0	0.000	-0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0	0.000	-0.075	0.050	0.025	0.000	0.025	0.000	-0.025	0.000
14	0	0.000	-0.050	0.000	-0.025	-0.025	0.025	0.025	-0.025	-0.025
15	0	0.000	-0.050	0.050	0.025	-0.025	-0.025	-0.025	0.000	0.025
16	0	0.000	-0.025	0.075	0.000	-0.025	0.025	0.025	0.025	0.025
17	0	0.025	-0.075	0.000	-0.025	-0.025	0.025	0.025	0.000	0.000
18	0	0.025	-0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0	0.025	-0.075	0.025	0.025	-0.025	-0.025	-0.025	0.000	0.025
20	0	0.025	-0.075	0.050	0.025	-0.025	-0.025	-0.025	0.000	0.000
21	0	0.025	-0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	0	0.025	-0.050	0.050	0.000	-0.025	-0.025	0.000	0.025	0.025
23	0	0.025	-0.050	0.050	0.025	0.000	0.000	-0.025	-0.025	0.000
24	0	0.025	-0.025	0.075	0.000	-0.025	0.025	0.025	0.025	0.025
25	0	0.050	-0.075	0.000	0.000	-0.025	0.000	0.000	0.025	0.025
26	0	0.050	-0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000

27	0	0.050	-0.075	0.025	0.025	-0.025	0.000	0.000	-0.025	0.000
28	0	0.050	-0.075	0.025	0.025	-0.025	0.000	0.000	0.025	0.025
29	0	0.050	-0.075	0.025	0.025	0.000	0.000	-0.025	-0.025	0.000
30	0	0.050	-0.075	0.025	0.025	0.000	0.025	0.025	0.025	0.025
31	0	0.050	-0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000
32	0	0.050	-0.025	-0.025	-0.025	-0.025	0.025	0.025	0.000	-0.025
33	0	0.050	-0.025	0.075	0.025	-0.025	0.025	0.025	0.025	0.025
34	0	0.075	0.050	-0.025	-0.025	0.000	0.000	0.000	0.000	0.000
35	0	0.075	-0.075	-0.025	-0.025	0.000	0.025	0.000	0.000	0.000
36	0	0.075	-0.075	-0.025	0.000	0.000	0.025	0.025	0.000	0.000
37	0	0.075	-0.075	0.000	0.000	-0.025	-0.025	0.000	0.000	0.000
38	0	0.075	-0.075	0.000	0.000	-0.025	0.000	0.000	0.000	0.000
39	0	0.075	-0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40	0	0.075	-0.075	0.000	0.025	-0.025	-0.025	0.000	0.000	0.000
41	0	0.075	-0.075	0.000	0.025	-0.025	0.000	0.000	0.000	0.000
42	0	0.075	-0.050	-0.050	-0.025	0.000	0.000	0.025	0.000	-0.025
43	0	0.075	-0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000
44	0	0.075	-0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000
45	0	0.075	-0.025	0.050	0.000	-0.025	0.025	0.025	0.000	0.000
46	0	0.100	-0.075	-0.050	-0.025	0.000	0.025	0.025	-0.025	-0.025
47	0	0.100	-0.075	-0.050	0.000	0.000	0.025	0.025	-0.025	-0.025
48	0	0.100	-0.075	-0.025	0.000	0.000	0.000	0.000	0.000	0.000
49	0	0.100	-0.075	-0.025	0.000	0.000	0.025	0.000	0.000	0.000
50	0	0.100	-0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000
51	0	0.100	-0.075	0.000	0.025	-0.025	-0.025	0.025	0.025	0.000
52	0	0.100	-0.050	-0.050	-0.025	0.000	-0.025	-0.025	-0.025	-0.025
53	0	0.100	-0.050	-0.025	-0.025	-0.025	0.025	0.000	-0.025	0.000
54	0	0.100	-0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55	0	0.100	-0.050	0.000	0.000	0.000	0.025	0.025	0.000	0.000

56	0	0.100	-0.050	0.000	0.000	0.000	0.025	0.025	0.025	0.025
57	0	0.100	-0.050	0.000	0.025	0.025	0.000	-0.025	-0.025	-0.025
58	0	0.100	-0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000
59	0	0.100	-0.025	0.000	0.025	0.025	0.000	-0.025	-0.025	-0.025
60	0	0.100	-0.025	0.025	-0.025	-0.025	0.025	0.025	0.000	0.000
61	0	0.100	0.000	0.000	-0.025	0.000	0.025	0.000	0.000	0.025
62	0	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63	0	0.100	0.000	0.050	0.000	-0.025	0.025	0.000	-0.025	0.000
64	0	0.125	-0.075	-0.075	-0.025	0.000	0.025	0.025	-0.025	-0.025
65	0	0.125	-0.075	-0.075	0.000	0.000	0.000	0.000	0.000	0.000
66	0	0.125	-0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000
67	0	0.125	-0.050	-0.025	-0.025	-0.025	0.000	0.000	0.000	0.000
68	0	0.125	-0.050	-0.025	-0.025	-0.025	0.025	0.000	0.000	0.000
69	0	0.125	-0.050	-0.025	0.000	0.000	0.025	0.025	0.000	0.000
70	0	0.125	-0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000
71	0	0.125	-0.050	0.000	0.025	0.025	0.025	0.000	0.000	0.000
72	0	0.125	-0.025	0.000	-0.025	-0.025	0.000	0.000	-0.025	-0.025
73	0	0.125	-0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000
74	0	0.125	-0.025	0.025	0.000	-0.025	0.000	0.000	0.000	0.000
75	0	0.125	-0.025	0.025	0.000	0.000	0.025	0.025	0.000	0.000
76	0	0.125	-0.025	0.025	0.025	0.025	-0.025	0.025	0.025	0.025
77	0	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
78	0	0.125	0.000	0.025	-0.025	-0.025	0.025	0.000	-0.025	-0.025

Section 25: Appendix B – through focus RIQ for combinations of spherical aberration in Appendix A

Combination	-1.50	-1.25	-1.00	-0.75	-0.50	-0.25	0.00	0.25	0.50	0.75	1.00	1.25	1.50
No Aberr	0.024	0.040	0.073	0.148	0.307	0.709	1.000	0.709	0.307	0.148	0.073	0.040	0.024
1	0.089	0.135	0.192	0.243	0.304	0.434	0.606	0.667	0.542	0.329	0.152	0.056	0.021
2	0.084	0.131	0.196	0.265	0.346	0.482	0.643	0.676	0.514	0.281	0.113	0.036	0.012
3	0.028	0.053	0.115	0.258	0.473	0.628	0.648	0.595	0.479	0.310	0.161	0.071	0.028
4	0.039	0.067	0.153	0.313	0.458	0.493	0.477	0.492	0.470	0.361	0.220	0.112	0.052
5	0.082	0.128	0.198	0.281	0.384	0.532	0.675	0.675	0.481	0.236	0.080	0.021	0.006
6	0.100	0.129	0.157	0.246	0.402	0.514	0.542	0.559	0.515	0.338	0.146	0.051	0.024
7	0.083	0.129	0.199	0.289	0.412	0.576	0.704	0.666	0.445	0.196	0.054	0.010	0.002
8	0.069	0.105	0.176	0.305	0.479	0.603	0.614	0.565	0.454	0.262	0.099	0.030	0.010
9	0.124	0.168	0.181	0.212	0.338	0.502	0.579	0.579	0.508	0.319	0.117	0.027	0.016
10	0.089	0.133	0.201	0.293	0.425	0.607	0.730	0.656	0.409	0.161	0.034	0.003	0.001
11	0.104	0.159	0.199	0.247	0.359	0.508	0.581	0.570	0.502	0.326	0.125	0.035	0.023
12	0.098	0.141	0.206	0.293	0.423	0.618	0.749	0.649	0.377	0.134	0.021	0.001	0.002
13	0.157	0.206	0.250	0.282	0.354	0.482	0.542	0.480	0.364	0.232	0.120	0.060	0.032
14	0.092	0.184	0.314	0.371	0.390	0.505	0.592	0.481	0.297	0.204	0.161	0.097	0.041
15	0.153	0.215	0.247	0.261	0.324	0.453	0.533	0.514	0.447	0.307	0.129	0.038	0.025
16	0.152	0.207	0.237	0.260	0.363	0.509	0.531	0.442	0.363	0.265	0.137	0.056	0.029
17	0.158	0.218	0.286	0.308	0.324	0.457	0.611	0.564	0.352	0.181	0.101	0.048	0.011
18	0.111	0.152	0.213	0.293	0.410	0.604	0.754	0.650	0.356	0.113	0.013	0.004	0.004
19	0.168	0.205	0.235	0.285	0.367	0.476	0.539	0.482	0.365	0.253	0.138	0.052	0.023
20	0.161	0.202	0.237	0.282	0.361	0.468	0.518	0.465	0.378	0.267	0.124	0.038	0.019
21	0.081	0.116	0.174	0.255	0.405	0.680	0.878	0.715	0.342	0.093	0.015	0.002	0.001

22	0.151	0.212	0.253	0.256	0.304	0.463	0.584	0.514	0.360	0.223	0.095	0.016	0.003
23	0.153	0.205	0.242	0.255	0.316	0.493	0.638	0.563	0.363	0.201	0.096	0.041	0.023
24	0.159	0.214	0.250	0.256	0.322	0.476	0.548	0.465	0.357	0.251	0.127	0.046	0.021
25	0.158	0.201	0.231	0.253	0.312	0.472	0.648	0.612	0.359	0.141	0.075	0.067	0.043
26	0.126	0.166	0.222	0.293	0.388	0.567	0.739	0.657	0.350	0.099	0.008	0.005	0.006
27	0.161	0.203	0.236	0.253	0.304	0.475	0.648	0.593	0.370	0.190	0.091	0.039	0.015
28	0.164	0.201	0.226	0.253	0.323	0.472	0.604	0.547	0.352	0.197	0.112	0.058	0.031
29	0.171	0.206	0.240	0.274	0.328	0.463	0.608	0.564	0.362	0.193	0.094	0.036	0.012
30	0.171	0.206	0.231	0.259	0.326	0.475	0.626	0.589	0.363	0.150	0.057	0.031	0.015
31	0.097	0.135	0.192	0.268	0.389	0.628	0.848	0.728	0.347	0.078	0.006	0.001	0.003
32	0.074	0.134	0.238	0.370	0.462	0.553	0.624	0.516	0.286	0.156	0.129	0.096	0.052
33	0.159	0.212	0.245	0.251	0.305	0.461	0.564	0.496	0.375	0.264	0.138	0.048	0.019
34	0.022	0.044	0.114	0.279	0.496	0.623	0.634	0.591	0.479	0.310	0.160	0.069	0.030
35	0.161	0.200	0.244	0.318	0.404	0.493	0.584	0.550	0.352	0.162	0.072	0.032	0.009
36	0.151	0.217	0.289	0.353	0.390	0.455	0.568	0.563	0.373	0.173	0.080	0.042	0.013
37	0.151	0.206	0.264	0.304	0.336	0.450	0.630	0.628	0.372	0.127	0.038	0.014	0.004
38	0.164	0.211	0.254	0.279	0.309	0.455	0.681	0.686	0.400	0.126	0.027	0.011	0.005
39	0.142	0.181	0.232	0.292	0.364	0.512	0.699	0.664	0.364	0.097	0.005	0.006	0.008
40	0.155	0.222	0.286	0.331	0.369	0.465	0.601	0.579	0.365	0.172	0.085	0.037	0.008
41	0.151	0.204	0.251	0.282	0.320	0.459	0.661	0.659	0.405	0.163	0.062	0.031	0.018
42	0.118	0.171	0.252	0.367	0.460	0.506	0.539	0.496	0.329	0.166	0.098	0.069	0.035
43	0.115	0.156	0.212	0.283	0.376	0.563	0.784	0.729	0.371	0.080	0.001	0.003	0.005
44	0.086	0.126	0.186	0.272	0.392	0.602	0.826	0.761	0.391	0.094	0.012	0.005	0.001
45	0.153	0.203	0.257	0.284	0.316	0.452	0.609	0.566	0.367	0.207	0.104	0.035	0.011

46	0.180	0.256	0.316	0.408	0.497	0.493	0.427	0.336	0.212	0.122	0.109	0.104	0.064
47	0.171	0.253	0.325	0.407	0.458	0.443	0.429	0.400	0.289	0.173	0.131	0.112	0.066
48	0.151	0.211	0.281	0.358	0.417	0.470	0.566	0.585	0.397	0.155	0.035	0.004	0.004
49	0.155	0.203	0.255	0.330	0.407	0.472	0.560	0.561	0.375	0.168	0.075	0.042	0.018
50	0.159	0.197	0.240	0.289	0.339	0.449	0.636	0.663	0.396	0.110	0.005	0.007	0.009
51	0.185	0.272	0.360	0.392	0.353	0.357	0.461	0.486	0.330	0.168	0.108	0.077	0.037
52	0.096	0.141	0.222	0.351	0.472	0.508	0.515	0.524	0.412	0.196	0.057	0.024	0.021
53	0.158	0.206	0.242	0.306	0.392	0.462	0.534	0.533	0.381	0.208	0.116	0.063	0.025
54	0.134	0.177	0.231	0.296	0.365	0.494	0.694	0.710	0.409	0.101	0.001	0.004	0.007
55	0.152	0.204	0.259	0.316	0.366	0.464	0.626	0.630	0.369	0.110	0.031	0.028	0.016
56	0.161	0.207	0.253	0.290	0.338	0.458	0.619	0.607	0.360	0.117	0.033	0.027	0.022
57	0.143	0.197	0.268	0.357	0.426	0.471	0.522	0.486	0.298	0.128	0.086	0.078	0.044
58	0.105	0.151	0.214	0.299	0.398	0.542	0.721	0.717	0.423	0.123	0.017	0.003	0.003
59	0.110	0.169	0.259	0.371	0.457	0.518	0.571	0.515	0.302	0.113	0.068	0.073	0.053
60	0.158	0.202	0.246	0.308	0.374	0.455	0.553	0.536	0.366	0.196	0.093	0.030	0.008
61	0.118	0.160	0.205	0.284	0.407	0.520	0.588	0.569	0.421	0.224	0.088	0.026	0.007
62	0.076	0.119	0.189	0.297	0.437	0.593	0.722	0.683	0.425	0.165	0.053	0.021	0.006
63	0.156	0.207	0.243	0.258	0.318	0.460	0.563	0.511	0.364	0.236	0.140	0.075	0.044
64	0.194	0.280	0.335	0.402	0.502	0.516	0.402	0.272	0.179	0.124	0.113	0.113	0.086
65	0.155	0.251	0.353	0.432	0.463	0.418	0.355	0.368	0.387	0.303	0.163	0.062	0.021
66	0.175	0.210	0.246	0.284	0.316	0.385	0.554	0.643	0.439	0.141	0.009	0.008	0.010
67	0.163	0.214	0.265	0.328	0.402	0.466	0.529	0.536	0.389	0.186	0.072	0.031	0.009
68	0.163	0.201	0.232	0.294	0.397	0.476	0.522	0.506	0.365	0.192	0.103	0.062	0.031
69	0.157	0.220	0.281	0.355	0.428	0.468	0.519	0.533	0.375	0.160	0.065	0.050	0.032

70	0.153	0.198	0.248	0.304	0.354	0.431	0.590	0.664	0.449	0.143	0.010	0.005	0.008
71	0.153	0.201	0.261	0.343	0.412	0.458	0.535	0.552	0.372	0.143	0.051	0.040	0.024
72	0.151	0.207	0.259	0.316	0.391	0.466	0.517	0.487	0.353	0.210	0.114	0.042	0.006
73	0.126	0.176	0.241	0.320	0.401	0.489	0.609	0.645	0.446	0.168	0.033	0.005	0.004
74	0.161	0.203	0.237	0.270	0.333	0.456	0.608	0.618	0.406	0.179	0.081	0.038	0.010
75	0.159	0.202	0.243	0.289	0.349	0.456	0.592	0.584	0.367	0.145	0.046	0.010	0.003
76	0.076	0.148	0.260	0.351	0.375	0.411	0.515	0.518	0.321	0.134	0.082	0.053	0.008
77	0.096	0.147	0.224	0.329	0.451	0.554	0.619	0.595	0.422	0.202	0.074	0.027	0.007
78	0.160	0.216	0.272	0.318	0.372	0.434	0.455	0.411	0.344	0.276	0.169	0.060	0.018

Section 26: Appendix C – example combinations of spherical aberration

Combination	C (2,0)	C(4,0)	C(6,0)	C(8,0)	C(10,0)	C(12,0)	C(14,0)	C(16,0)	C(18,0)	C(20,0)
No Aberr	0	0	0	0	0	0	0	0	0	0
101	0	-0.125	-0.075	0.000	0.025	-0.025	-0.025	0.025	0.000	-0.025
102	0	-0.125	-0.050	0.000	0.025	0.000	-0.025	0.025	0.000	-0.025
103	0	-0.125	-0.050	0.000	0.025	0.000	-0.025	0.025	0.025	-0.025
104	0	-0.125	-0.050	0.025	0.025	-0.025	-0.025	0.025	0.000	-0.025
105	0	-0.125	-0.050	0.050	0.025	-0.025	0.000	0.025	-0.025	-0.025
106	0	-0.125	-0.050	0.050	0.025	-0.025	0.025	0.000	0.000	0.025
107	0	-0.125	-0.025	-0.025	0.025	0.025	-0.025	0.000	0.025	0.000
108	0	-0.125	-0.025	0.000	0.000	0.025	-0.025	-0.025	0.025	0.025
109	0	-0.125	-0.025	0.000	0.000	0.025	0.000	-0.025	0.025	0.025
110	0	-0.125	-0.025	0.000	0.025	0.025	-0.025	-0.025	0.025	0.000
111	0	-0.125	-0.025	0.000	0.025	0.025	-0.025	0.000	0.025	0.000
112	0	-0.125	-0.025	0.000	0.025	0.025	-0.025	0.025	0.025	0.000
113	0	-0.125	-0.025	0.025	0.025	0.000	-0.025	0.025	0.025	-0.025
114	0	-0.125	-0.025	0.075	0.025	-0.025	0.025	0.000	0.000	0.025
115	0	-0.125	0.000	0.050	0.025	0.000	-0.025	0.025	0.025	-0.025
116	0	-0.125	0.000	0.075	0.025	-0.025	-0.025	0.025	0.000	-0.025
117	0	-0.125	0.050	0.075	0.025	0.025	0.000	0.000	0.000	-0.025
118	0	-0.125	0.075	0.075	-0.025	0.000	-0.025	-0.025	0.000	0.000
119	0	-0.100	-0.075	-0.050	0.025	0.025	-0.025	-0.025	0.025	0.025
120	0	-0.100	-0.050	-0.050	0.025	0.025	-0.025	-0.025	0.025	0.025
121	0	-0.100	-0.050	-0.025	0.025	0.025	-0.025	-0.025	0.025	0.025
122	0	-0.100	-0.025	-0.050	0.025	0.025	-0.025	-0.025	0.025	0.000
123	0	-0.100	-0.025	-0.025	0.000	0.025	-0.025	-0.025	0.025	0.025
124	0	-0.100	-0.025	-0.025	0.025	0.025	-0.025	-0.025	0.025	0.000
125	0	-0.100	0.050	0.075	-0.025	-0.025	-0.025	-0.025	-0.025	0.000
126	0	-0.100	0.075	0.075	-0.025	0.000	-0.025	-0.025	0.000	0.000

127	0	-0.100	0.075	0.075	0.000	0.000	-0.025	-0.025	-0.025	-0.025
128	0	-0.100	0.075	0.075	0.000	0.000	-0.025	-0.025	0.000	-0.025
129	0	-0.075	0.025	0.075	0.025	-0.025	-0.025	0.025	-0.025	-0.025
130	0	-0.075	0.050	0.075	-0.025	-0.025	0.000	-0.025	0.000	0.025
131	0	-0.075	0.050	0.075	-0.025	-0.025	0.025	0.000	0.025	0.025
132	0	-0.075	0.050	0.075	0.025	-0.025	-0.025	0.000	-0.025	-0.025
133	0	-0.075	0.050	0.075	0.025	0.000	-0.025	0.025	0.000	-0.025
134	0	-0.075	0.075	0.075	-0.025	-0.025	-0.025	-0.025	0.000	0.000
135	0	-0.075	0.075	0.075	-0.025	-0.025	-0.025	-0.025	0.000	0.025
136	0	-0.075	0.075	0.075	-0.025	-0.025	0.000	-0.025	0.025	0.025
137	0	-0.075	0.075	0.075	-0.025	-0.025	0.000	0.000	0.000	0.025
138	0	-0.075	0.075	0.075	-0.025	-0.025	0.025	0.000	0.000	0.025
139	0	-0.075	0.075	0.075	-0.025	-0.025	0.025	0.000	0.025	0.025
140	0	-0.050	-0.050	-0.075	0.025	0.025	-0.025	0.000	0.000	0.000
141	0	-0.050	0.050	0.075	-0.025	-0.025	0.000	-0.025	0.000	0.025
142	0	-0.050	0.050	0.075	-0.025	-0.025	0.000	-0.025	0.025	0.025
143	0	-0.050	0.050	0.075	0.025	-0.025	-0.025	0.025	-0.025	-0.025
144	0	-0.050	0.075	0.075	-0.025	-0.025	-0.025	-0.025	0.025	0.025
145	0	-0.050	0.075	0.075	-0.025	-0.025	0.025	0.000	0.000	0.025
146	0	-0.050	0.075	0.075	-0.025	-0.025	0.025	0.000	0.025	0.025
147	0	-0.025	0.075	0.075	-0.025	-0.025	0.025	0.000	0.000	0.025
148	0	-0.025	0.075	0.075	-0.025	-0.025	0.025	0.000	0.025	0.025
149	0	0.000	0.075	0.075	-0.025	-0.025	0.025	0.000	0.000	0.025
150	0	0.000	0.075	0.075	-0.025	-0.025	0.025	0.000	0.025	0.025
151	0	0.025	-0.050	-0.075	0.025	0.025	0.025	0.025	-0.025	-0.025
152	0	0.050	0.075	-0.050	-0.025	0.025	-0.025	-0.025	-0.025	-0.025
153	0	0.075	0.075	-0.050	0.000	0.025	-0.025	-0.025	-0.025	-0.025
154	0	0.100	0.050	-0.075	-0.025	0.000	-0.025	0.025	0.000	0.000
155	0	0.100	0.050	-0.075	-0.025	0.025	0.000	0.025	0.000	-0.025

156	0	0.100	0.050	-0.075	-0.025	0.025	0.025	0.025	0.025	0.000
157	0	0.100	0.050	-0.075	0.000	0.025	0.000	0.000	-0.025	-0.025
158	0	0.100	0.075	-0.075	-0.025	0.000	-0.025	0.000	0.000	0.000
159	0	0.100	0.075	-0.075	-0.025	0.025	0.000	0.025	0.025	0.000
160	0	0.100	0.075	-0.075	-0.025	0.025	0.025	0.025	0.025	0.025
161	0	0.125	0.050	-0.075	0.000	-0.025	-0.025	0.000	0.000	0.000
162	0	0.125	0.075	-0.075	-0.025	0.000	-0.025	-0.025	0.000	0.000
163	0	0.125	0.075	-0.075	-0.025	0.000	-0.025	0.000	0.000	0.000
164	0	0.125	0.075	-0.050	0.000	0.000	-0.025	0.000	-0.025	-0.025
165	0	0.125	0.075	-0.050	0.000	0.000	-0.025	0.000	-0.025	0.000
166	0	0.125	0.075	-0.050	0.000	0.000	-0.025	0.000	0.000	0.000
167	0	0.125	0.075	-0.050	0.000	0.000	-0.025	0.000	0.025	0.025

Section 27: Appendix D: Through focus RIQ for combinations of spherical aberration in Appendix C

Combination	-1.50	-1.25	-1.00	-0.75	-0.50	-0.25	0.00	0.25	0.50	0.75	1.00	1.25	1.50
No Aberr	0.024	0.040	0.073	0.148	0.307	0.709	1.000	0.709	0.307	0.148	0.073	0.040	0.024
101	0.071	0.102	0.206	0.371	0.466	0.446	0.409	0.397	0.365	0.305	0.236	0.171	0.114
102	0.075	0.113	0.213	0.357	0.421	0.407	0.430	0.459	0.402	0.301	0.220	0.160	0.110
103	0.071	0.106	0.224	0.382	0.431	0.388	0.385	0.405	0.374	0.309	0.238	0.173	0.120
104	0.045	0.079	0.216	0.430	0.524	0.446	0.376	0.385	0.383	0.326	0.240	0.161	0.106
105	0.043	0.075	0.203	0.427	0.551	0.478	0.377	0.355	0.350	0.314	0.242	0.160	0.101
106	0.045	0.108	0.230	0.382	0.459	0.413	0.366	0.386	0.382	0.312	0.221	0.151	0.109
107	0.032	0.091	0.212	0.323	0.360	0.391	0.463	0.483	0.407	0.317	0.255	0.198	0.141
108	0.044	0.109	0.239	0.330	0.354	0.389	0.444	0.462	0.422	0.347	0.264	0.183	0.111
109	0.029	0.106	0.231	0.314	0.358	0.427	0.489	0.478	0.403	0.321	0.251	0.176	0.107
110	0.028	0.098	0.234	0.343	0.359	0.364	0.439	0.503	0.447	0.324	0.232	0.168	0.109
111	0.033	0.093	0.221	0.343	0.385	0.402	0.469	0.514	0.446	0.326	0.234	0.168	0.113
112	0.049	0.091	0.202	0.327	0.384	0.405	0.450	0.467	0.400	0.303	0.223	0.163	0.116
113	0.048	0.082	0.211	0.400	0.476	0.408	0.365	0.391	0.387	0.325	0.239	0.167	0.118
114	0.044	0.095	0.211	0.386	0.486	0.426	0.358	0.375	0.370	0.305	0.231	0.167	0.119
115	0.053	0.096	0.212	0.360	0.420	0.374	0.361	0.416	0.420	0.340	0.239	0.164	0.119
116	0.067	0.121	0.220	0.342	0.392	0.355	0.361	0.434	0.455	0.389	0.277	0.169	0.101
117	0.039	0.095	0.206	0.321	0.369	0.365	0.383	0.422	0.418	0.358	0.268	0.180	0.120
118	0.061	0.120	0.212	0.315	0.388	0.387	0.350	0.353	0.365	0.344	0.304	0.244	0.168
119	0.065	0.127	0.213	0.309	0.364	0.393	0.432	0.436	0.395	0.342	0.269	0.183	0.111
120	0.040	0.098	0.211	0.322	0.354	0.366	0.412	0.425	0.391	0.355	0.296	0.204	0.125
121	0.039	0.104	0.236	0.352	0.374	0.383	0.441	0.469	0.426	0.351	0.264	0.173	0.102

122	0.028	0.085	0.205	0.324	0.362	0.371	0.405	0.413	0.372	0.322	0.267	0.194	0.125
123	0.039	0.083	0.201	0.313	0.367	0.431	0.486	0.458	0.392	0.348	0.288	0.192	0.105
124	0.020	0.075	0.204	0.339	0.396	0.417	0.452	0.459	0.403	0.317	0.242	0.172	0.107
125	0.044	0.096	0.203	0.327	0.395	0.383	0.359	0.389	0.423	0.393	0.304	0.194	0.101
126	0.057	0.106	0.205	0.327	0.410	0.411	0.368	0.358	0.369	0.346	0.293	0.224	0.147
127	0.038	0.087	0.200	0.338	0.402	0.383	0.367	0.388	0.397	0.359	0.282	0.194	0.123
128	0.037	0.097	0.206	0.319	0.378	0.380	0.379	0.396	0.381	0.319	0.250	0.188	0.134
129	0.053	0.097	0.219	0.353	0.404	0.378	0.365	0.397	0.395	0.323	0.235	0.163	0.112
130	0.050	0.106	0.211	0.342	0.446	0.474	0.421	0.381	0.381	0.347	0.267	0.179	0.109
131	0.058	0.121	0.201	0.302	0.420	0.465	0.419	0.397	0.393	0.330	0.238	0.161	0.104
132	0.025	0.082	0.215	0.346	0.385	0.372	0.406	0.470	0.463	0.365	0.248	0.158	0.104
133	0.059	0.103	0.205	0.318	0.370	0.369	0.394	0.451	0.437	0.328	0.219	0.151	0.109
134	0.045	0.095	0.210	0.336	0.389	0.380	0.383	0.424	0.441	0.388	0.295	0.199	0.116
135	0.046	0.094	0.209	0.331	0.379	0.374	0.371	0.392	0.413	0.383	0.303	0.207	0.121
136	0.048	0.102	0.208	0.326	0.393	0.391	0.358	0.355	0.377	0.356	0.289	0.213	0.142
137	0.028	0.082	0.201	0.325	0.378	0.368	0.367	0.418	0.461	0.422	0.319	0.200	0.103
138	0.024	0.083	0.205	0.344	0.424	0.411	0.371	0.380	0.404	0.376	0.299	0.206	0.126
139	0.036	0.107	0.214	0.316	0.387	0.398	0.373	0.388	0.408	0.363	0.278	0.191	0.120
140	0.067	0.117	0.201	0.311	0.384	0.416	0.461	0.485	0.422	0.312	0.219	0.151	0.102
141	0.055	0.105	0.215	0.361	0.464	0.483	0.431	0.379	0.364	0.333	0.256	0.169	0.101
142	0.075	0.131	0.218	0.317	0.399	0.438	0.415	0.382	0.374	0.331	0.245	0.168	0.110
143	0.052	0.090	0.204	0.350	0.411	0.382	0.371	0.406	0.398	0.313	0.222	0.161	0.118
144	0.078	0.118	0.208	0.319	0.381	0.398	0.405	0.407	0.399	0.353	0.273	0.194	0.124
145	0.028	0.086	0.212	0.359	0.437	0.421	0.381	0.386	0.403	0.368	0.286	0.192	0.116

146	0.036	0.105	0.226	0.341	0.402	0.405	0.382	0.390	0.405	0.360	0.269	0.179	0.109
147	0.035	0.092	0.218	0.372	0.454	0.434	0.387	0.383	0.391	0.352	0.272	0.183	0.111
148	0.042	0.104	0.231	0.363	0.423	0.415	0.388	0.386	0.392	0.348	0.260	0.171	0.104
149	0.046	0.102	0.223	0.381	0.471	0.449	0.391	0.374	0.371	0.329	0.255	0.177	0.110
150	0.053	0.107	0.230	0.378	0.449	0.430	0.391	0.375	0.370	0.328	0.249	0.168	0.104
151	0.087	0.139	0.218	0.318	0.389	0.428	0.447	0.425	0.379	0.315	0.228	0.150	0.103
152	0.048	0.099	0.206	0.320	0.374	0.384	0.417	0.463	0.443	0.336	0.220	0.154	0.125
153	0.042	0.095	0.205	0.324	0.375	0.387	0.427	0.466	0.430	0.318	0.209	0.153	0.130
154	0.075	0.124	0.201	0.316	0.436	0.454	0.387	0.368	0.367	0.303	0.217	0.152	0.104
155	0.072	0.118	0.205	0.348	0.488	0.481	0.376	0.359	0.381	0.320	0.222	0.157	0.118
156	0.040	0.096	0.200	0.357	0.504	0.508	0.407	0.366	0.363	0.301	0.213	0.155	0.119
157	0.047	0.097	0.202	0.355	0.455	0.420	0.357	0.393	0.426	0.345	0.223	0.156	0.132
158	0.053	0.110	0.206	0.316	0.403	0.413	0.369	0.385	0.428	0.385	0.276	0.183	0.122
159	0.071	0.127	0.209	0.315	0.415	0.418	0.355	0.370	0.417	0.368	0.260	0.175	0.126
160	0.050	0.107	0.206	0.329	0.429	0.429	0.363	0.363	0.389	0.335	0.236	0.164	0.125
161	0.056	0.121	0.211	0.304	0.386	0.420	0.400	0.393	0.387	0.319	0.226	0.161	0.121
162	0.055	0.122	0.222	0.313	0.355	0.361	0.363	0.401	0.449	0.410	0.285	0.170	0.107
163	0.063	0.129	0.233	0.335	0.403	0.411	0.363	0.354	0.400	0.387	0.291	0.189	0.118
164	0.062	0.106	0.202	0.330	0.412	0.421	0.394	0.375	0.371	0.348	0.275	0.177	0.105
165	0.050	0.107	0.217	0.345	0.423	0.426	0.379	0.351	0.361	0.332	0.240	0.151	0.101
166	0.047	0.105	0.201	0.312	0.411	0.459	0.438	0.418	0.420	0.366	0.262	0.173	0.112
167	0.053	0.119	0.210	0.307	0.405	0.466	0.447	0.416	0.394	0.311	0.212	0.161	0.122

Claims

1. A lens for an eye, the lens having an optical axis, a focal distance and being characterised by:

an aberration profile along the optical axis, the aberration profile:

including higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), herein the aberration profile provides, for a model eye with no aberrations and an on-axis length equal to the focal distance:

a retinal image quality (RIQ) with a through focus slope that degrades in a direction of eye growth; and

a RIQ of at least 0.3

wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

2. A lens for an eye, the lens having an optical axis, a focal distance and being characterised by an aberration profile about the optical axis, the aberration profile :

including higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), herein the aberration profile provides, for a model eye with no aberrations and an on-axis length equal to the focal distance:

a retinal image quality (RIQ) with a through focus slope that improves in a direction of eye growth; and

a RIQ of at least 0.3;

wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

3. The lens of claim 1, wherein the focal distance is a prescription focal distance for a myopic eye and wherein the focal distance differs from the focal distance for a C(2,0) Zernike coefficient of the aberration profile.

4. The lens of claim 2, wherein the focal distance is a prescription focal distance for a hyperopic eye and wherein the focal distance differs from the focal distance for a C(2,0) Zernike coefficient of the aberration profile.

5. The lens of claim 1, wherein the lens is used for myopia control with or without astigmatism.

6. The lens of claim 2, wherein the lens is used for hyperopia treatment with or without astigmatism.

7. The lens of any one of claims 1 to 6, wherein the higher order aberrations include at least two spherical aberration terms selected from the group C(4,0) to C(20,0).

8. The lens of any one of claims 1 to 6, wherein the higher order aberrations include at least three spherical aberration terms selected from the group C(4,0) to C(20,0).

9. The lens of any one of claims 1 to 8, wherein the magnitude of higher order aberrations included is at least 0.02 μm over a 3 mm, 4 mm, 5 mm or 6 mm pupil diameter.

10. The lens of claim 1, claim 3, claim 5, or any one of claims 7 to 9 when dependent on claim 1, wherein the average slope over a horizontal field of at least -20° to +20° degrades in a direction of eye growth.

11. The lens of claim 1, claim 3, claim 5, claim 10 or any one of claims 7 to 9 when dependent on claim 1, wherein the average slope over a vertical field of at least -20° to +20° degrades in a direction of eye growth.

12. The lens of claim 2, claim 4, or claim 6, or any one of claims 7 to 9 when dependent on claim 2, wherein the average slope over a horizontal field of at least -20° to +20° improves in a direction of eye growth.

13. The lens of claim 2, claim 4, claim 6, or claim 12, or any one of claims 7 to 9 when dependent on claim 2, wherein the average slope over a vertical field of at least -20° to +20° improves in a direction of eye growth.

14. The lens of any one of the preceding claims, wherein the aberration profile provides a RIQ of at least 0.3 at the focal length substantially across the pupil diameters in the range 3 mm to 6 mm.

15. The lens of any one of the preceding claims, wherein the aberration profile provides a RIQ with a through focus slope that degrades in a direction of eye growth when at least one of primary and secondary astigmatism is added to the aberration profile.

16. The lens of any one of the preceding claims, wherein the RIQ is characterised by:

$$RIQ = \frac{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * W(\rho,\theta)\right]\right\}|^2))))}{\iint_{-Fmin}^{+Fmax} CSF(x,y) * (((FT(|FT\left\{A(\rho,\theta) * \exp\left[\frac{2\pi i}{\lambda} * Wdiff(\rho,\theta)\right]\right\}|^2))))},$$

wherein:

Fmin is 0 cycles/degree and *Fmax* is 30 cycles/degree;

CSF(x, y) denotes the contrast sensitivity function

$CSF(F)=2.6(0.0192+0.114f)e^{-(0.114f)^{1.1}}$;

where *f* specifies the tested spatial frequency, in the range of F_{min} to F_{max};

FT denotes a 2D fast Fourier transform;

$A(\rho,\theta)$ denotes the pupil diameter;

$W(\rho,\theta)$ denotes wavefront phase of the test case measured for i=1 to 20;

$$W(\rho,\theta) = \sum_{i=1}^{k} a_i Z_i(\rho,\theta)$$

Wdiff(ρ, θ) denotes wavefront phase of the diffraction limited case;

ρ and θ are normalised polar coordinates, where ρ represents the radial coordinate and θ represents the angular coordinate or azimuth; and λ denotes wavelength.

17. A lens for an eye, the lens having an optical axis, a focal distance and being characterised by:

an aberration profile about the optical axis;

the aberration profile including higher order aberrations having at least one of a primary spherical aberration component C(4,0) and a secondary spherical aberration component C(6,0), wherein the aberration profile provides, for a model eye with no aberrations and an on-axis length equal to the focal distance:

a peak Visual Strehl Ratio (first Visual Strehl Ratio) within a through focus range;

a Visual Strehl Ratio that remains at or above a second Visual Strehl Ratio over the through focus range that includes said focal distance, wherein the first Visual Strehl Ratio is at least 0.35, the second Visual Strehl Ratio is at least 0.1 and the through focus range is at least 1.8 Dioptres; and

wherein the RIQ is Visual Strehl Ratio measured substantially along the optical axis for at least one pupil diameter in the range 3 mm to 6 mm, over a spatial frequency range of 0 to 30 cycles/degree inclusive and at a wavelength selected from within the range 540 nm to 590 nm inclusive.

18. The lens of claim 17, wherein the first Visual Strehl Ratio is selected from a group comprising: at least 0.4, at least 0.5, at least 0.6 and at least 0.7.

19. The lens of claim 17 or 18, wherein the first Visual Strehl Ratio is selected from a group comprising: at least 0.1, at least 0.12, at least 0.14, at least 0.16, at least 0.18 and at least 0.2.

20. The lens of any one of claims 17 to 19, wherein the through focus range is selected from a group comprising: at least 1.9, at least 2, at least 2.1, at least 2.2, at least 2.3, at least 2.4 and at least 2.5 Dioptres.

21. The lens of any one of claims 17 to 20, wherein the lens has a prescription focal distance located within 0.25 Dioptres of an end of the through focus range.

22. The lens of claim 21, wherein through focus range has a negative power end and positive power end and wherein the end of the through focus range is the negative power end.

23. The lens of claim 21, wherein through focus range has a negative power end and positive power end and wherein the end of the through focus range is the positive power end.

24. The lens of any one of claims 17 to 23, wherein the Visual Strehl Ratio remains at or above the second Visual Strehl Ratio over a range of pupil diameters of at least 1.5 mm.

25. The lens of any one of claims 17 to 24, wherein the combination of higher order aberrations includes at least one of primary spherical aberration and secondary spherical aberration.

26. The lens of any one of claims 17 to 24, wherein the higher order aberrations include at least two spherical aberration terms selected from the group C(4,0) to C(20,0).

27. The lens of any one of claims 17 to 24, wherein the higher order aberrations include at least three spherical aberration terms selected from the group C(4,0) to C(20,0).

28. The lens of any one of claims 17 to 27, wherein the RIQ for every field angle over a horizontal field of at least -20° to +20° is at least 0.3, 0.35 or 0.4.

29. A method for a myopic eye, with or without astigmatism, with a first set of aberrations comprising and providing for the eye, at least one of a lens, optical device, and altered corneal shape, a second combination of aberrations, the second combination of aberrations comprising higher order aberrations, wherein a total combination of the first and second combinations provides a through-focus retinal image quality that does not improve in the direction of eye growth.

30. The method of claim 29, wherein the total combination provides a through-focus retinal image quality that has instantaneous gradient at or near a retina of the eye that degrades in the direction of eye growth.

31. A method for a hyperopic eye, with or without astigmatism, with a first set of aberrations comprising providing, for the eye, at least one of a lens, optical device, and altered corneal shape, a second combination of aberrations, second combination of aberrations comprising higher order aberrations, wherein a total combination of the first and second combinations provides a through-focus retinal image quality that improves in the direction of eye growth.

32. The method of claim 31, wherein the total combination provides a through-focus retinal image quality that has instantaneous gradient at or near a retina of the eye that improves in the direction of eye growth.