[0017] FIG. 4A shows a schematic diagram illustrating a convergent light coming to a focus beyond the tips of photoreceptor outer segments (OS).

[0018] FIG. 4B shows a schematic diagram of the L-cone, M-cone and S-cone photoreceptor outer segments (OS), according to various embodiments.

[0019] FIG. 4C shows a schematic diagram of the L-cone, M-cone and S-cone photoreceptor OS in white light, according to various embodiments.

[0020] FIG. 4D shows a schematic diagram of the L-cone, M-cone and S-cone photoreceptor outer segments (OS) in the conditions of excess red light and a reduced blue light, according to various embodiments.

[0021] FIG. 5A shows a photograph of an enclosure and a system for chick rearing, while FIG. 5B shows a photograph of an interior of the enclosure, according to various embodiments.

[0022] FIG. 6 shows a plot illustrating the emission spectra of the light emitting diodes (LEDs) used for chick rearing according to various embodiments.

[0023] FIG. 7 shows a plot of histograms of mean refractive status of randomly selected eyes from each chick reared for 14 days, 21 days or 28 days in predominately red or predominately blue lighting conditions.

[0024] FIG. 8 shows a plot of histograms of mean refractive status of randomly selected eyes from each chick raised for 21 days in predominantly red light and subsequently for 21 days in predominantly blue light conditions.

[0025] FIG. 9 shows a plot of histograms of mean refractive status of randomly selected eyes from each chick raised for 21 days in predominantly blue light and subsequently for 21 days in predominantly red light conditions.

[0026] FIG. 10 shows a plot of histograms of the chromatic content of a same indoor scene lit by different illumination sources.

[0027] FIGs. 11A to 11E show photographs of various outdoor scenes with their respective chromatic content.

[0060] In various embodiments, the optical filter may be disposed on a surface of the ocular lens, for example on an outer surface of the ocular lens, distal to the eye of the viewer, or may be integral with the ocular lens.

[0061] In various embodiments, the ocular lens may be further configured for refractive correction. The ocular lens may be an aspheric lens. The ocular lens may be a spectacle lens or a contact lens.

[0062] In the context of various embodiments, the filtered light may further include a second light in a wavelength range of between about 550 nm and about 700 nm, for example with 1% or less of red wavelengths (i.e. 600 nm - 700 nm) or with 1% or less of red wavelengths (i.e. 600 nm or longer), and wherein an amount of the first light is higher than an amount of the second light.

[0063] In the context of various embodiments, the first peak wavelength may be about 480 nm and the second peak wavelength may be about 550 nm.

[0064] In the context of various embodiments, an amount of light having the first peak wavelength may be higher than an amount of light having the second peak wavelength.

[0065] In the context of various embodiments, the amount of light having the first peak wavelength is in a range of between about 80% and about 90%, for example about 90% and the amount of light having the second peak wavelength is in a range of between about 10% and about 20%, for example about 10%.

[0066] In the context of various embodiments, the first light may have a spectrum in a wavelength range of between about 460 nm and about 550 nm, for example a spectrum spanning at least substantially throughout the wavelength range (i.e. across the entire wavelength range) or spanning across a portion of the wavelength range, for example between about 480 nm to about 550 nm. In addition, the first light may have a spectrum biased towards the blue region, for example having at least one peak wavelength in a range of between about 460 nm and about 490 nm, for example at about 480 nm, while the spectrum of the first light also extends into the green region.

[0067] In the context of various embodiments, the first light may have a first peak wavelength in a range of between about 460 nm and about 500 nm, for example between about 470 nm and about 490 nm, for example a first peak wavelength at about 480 nm ±

20 nm, and a second peak wavelength in a range of between about 530 nm and about 570 nm, for example a second peak wavelength at about 550 nm ± 20 nm.

[0068] In the context of various embodiments, an amount of light having the first peak wavelength may be higher than an amount of light having the second peak wavelength. The amount of light having the first peak wavelength may be in a range of between about 80% and about 90% and the amount of light having the second peak wavelength may be in a range of between about 10% and about 20%.

[0069] In the context of various embodiments, the first peak wavelength and the second peak wavelength may be part of a continuous spectrum or may be part of separate spectra.

[0070] In the context of various embodiments, the second light may have a spectrum in a wavelength range of between about 530 nm and about 700 nm, for example with 1% or less of red wavelengths (i.e. 600 nm - 700 nm) or with 1% or less of red wavelengths (i.e. 600 nm or longer), for example a spectrum spanning at least substantially throughout the wavelength range (i.e. across the entire wavelength range) or spanning across a portion of the wavelength range, for example between about 550 nm and about 650 nm. The second light may have a peak wavelength in a range of between about 530 nm and about 570 nm, for example at about 550 nm.

[0071] In the context of various embodiments, the first light may have a first peak wavelength at about 480 nm ± 20 nm, and a second peak wavelength at about 550 nm ± 20 nm. The 550 nm green peak is near the peak or maximal sensitivity of the M-cones and substantially at the maximal spectral sensitivity of the light adapted eye so as to ensure that accommodation mediated by the M-cones lies at the mid-points of the M-cone outer segments (OS) as well as at the mid-points of the L-cones and the S-cones.

[0072] The first peak at about 480 nm is within the blue domain of the visible spectrum and near the maximal sensitivity of the S-cones and is provided so as to maximise the disparity between the photon catch at the bases of the S-cones compared to a low level of photon catch at the tips of the L-cones (for example in the absence of long wavelength red light).

[0073] The ratio of blue wavelengths to green wavelengths may be of the order of about 90% blue to about 10% green and less than about 1% red or no red.

[0074] In various embodiments, spectacle lenses and contact lenses may be designed and constructed and/or incorporate one or more filters to change the chromatic content of transmitted light so as to provide a chromatic content as described above. In other words, the changed chromatic content may have an increased content of blue light relative to red light or a decreased content of red light relative to blue light, while maintaining an adequacy of green content.

[0075] The spectacle lenses and the contact lenses may incorporate a refractive correction, and may be designed for continuous or near-continuous wear by children at risk of developing myopia or who have developed myopia or are at risk of progression of myopia. The contact lenses may be aspheric with the refractive correction provided by clear spectacle lenses having the desired refractive correction.

[0076] In various embodiments, light sources may be designed and constructed and/or modified and/or incorporate one or more filters to change the chromatic content of transmitted light so as to provide a chromatic content as described above. The light sources may be used for indoor activities (including use at home or in schools, for room lighting, illumination of white/black boards etc.), and may replace other forms of artificial lighting, so as to reduce the risk of development of childhood myopia or to reduce the risk of progression of myopia among those who have developed myopia.

[0077] In addition, light sources (e.g. reading lamps) may be designed and constructed and/or modified to incorporate light emitters, for example blue emitting LEDs or blue emitting fluorescent light sources, each with an emission spectrum having a chromatic content as described above, to be used (e.g. by children) during reading and other close work or other indoor activities.

[0078] In various embodiments, headgear for the young children to wear may be designed and constructed and/or modified to incorporate light emitters, for example with LEDs having an emission spectrum having a chromatic content as described above. The headgear may include the use of a headband mounted LED source with a parabolic reflector designed to illuminate an area involved in reading or other close work. The light intensity at the reading distance may be about 30 lux (e.g. about 3 foot candles).

[0079] In various embodiments, projection devices or display devices may be designed and constructed and/or modified and/or incorporate one or more filters to change the

chromatic content of transmitted light so as to provide a chromatic content as described above, for example for use in schools.

[0080] In various embodiments, the chromatic characteristics of computer screens for use by children in schools or at home may be designed or modified so as to provide a chromatic content as described above. This may be achieved, for example, by one or more filters applied to the screen or by computer software programmed to achieve the chromaticity as described above.

[0081] Therefore, altering the chromatic characteristics of light incident on the eye by the use of appropriate filters incorporated in spectacle lenses or contact lenses or by the application to spectacle lenses of appropriate filters to provide an incident light with an increased proportion of blue light as against red light, and an adequate proportion of green light, or by the use of artificial light sources modified so that they emit a greater proportion of blue light and a reduced proportion of red light (together with an adequate proportion of green light) may prevent or minimize the occurrence of the developing eye becoming myopic or if myopia has already developed, may prevent or minimize its further progression. In schools or home, for example involving indoor conditions lit by artificial light, modification of the lighting conditions to increase the proportion of blue light as against red light, and maintaining an adequate proportion of green light, may reduce the risk of myopia or prevent its progression. Modification to the spectral composition of computer displays may provide a similar effect.

[0082] Research into possible adverse effects of light has mostly been carried out on nocturnal rodents with rod dominated retinas and using high intensities of light, beyond the intensity of light in accordance with the various embodiments. It has been shown that in diurnal animals and primates such as macaques, exposure to even intense light fails to induce retinal damage. Children, like other higher primates are probably at a reduced risk of adverse retinal effects from blue light hazard (Organisciak DT,. Vaughan DK, Prog Retin Eye Res. 2019;29:113-34)

[0083] Although exposure of the eye to intense blue light at near damaging intensities may cause retinal damage and has been suggested as playing a role in retinal degenerative disorders of the elderly (so called blue light hazard), the blue/green light with a chromatic content in accordance with various embodiments to be used clinically in the management

of childhood myopia may be selected so as not to be associated with any adverse retinal effects.

[0084] The light intensity of various embodiments is about 3 foot candles, compared to light intensities which may induce retinal damage, characteristically between about 100-300 foot candles (about 1200 -3000+ lux).

[0085] Furthermore, outdoor activity has been shown to protect against the development of myopia and appears to carry no adverse risk of ocular damage. The light intensity of full daylight (and not direct sunlight) lies between 10,000 and 25,000 lux (approximately 950-2,300 foot candles). Thus, the intensity of light outdoors is about 300 to 1,000 times the light intensity of various embodiments of about 3 foot candles.

[0086] The light in accordance with various embodiments has a minimum wavelength (i.e. shortest wavelength) at about 460 nm, which is longer than the wavelengths shown to carry the highest risk of retinal damage, for example near ultra violet (UV) or very short wave blue light of about 360 nm to about 430 nm.

[0087] The chromatic manipulation and the light used in accordance with various embodiments may be used during daylight hours and early evening, preferably not at night, where in animals, it has been shown that the retina is at greatest risk of light damage where light exposure is during the night with a peak sensitivity at 1 am.

Examples

[0088] Modifying the ratios of long to short wavelength light while maintaining an adequate proportion of green light may ensure that the focal plane for the green wavelengths from distant objects lie midway along all of the photoreceptor OS. Such an approach may help to determine the effects of chromaticity on ocular and refractive development and its refractive status.

[0089] In order to obtain a significant imbalance between photon density at the tips and bases of the OS, chicks were raised in light that had an adequate proportion of green light to maintain the focus of green wavelengths in the mid-points of all OS. In addition to the green light, there was a preponderance of either red light or blue light (e.g. having an excess red light or an excess blue light).

[0090] Although there are differences between avian and mammalian eyes, the chick has a cone dominated retina and a spectral sensitivity curve that substantially matches that in the human, although determined by five colour responsive cones (Pask C, Stacey A., Vision Res 1998;38:953-961) compared to the three types of cones in the human retina.

[0091] The young chick eye may respond quickly to alterations in the visual input, visual deprivation for example, thereby causing myopia within a period of two weeks.

[0092] FIG. 5A shows a photograph 500 of an enclosure 502 and a system for chick rearing, while FIG. 5B shows a photograph 520 of an interior of the enclosure 502, according to various embodiments. The system may include a closed-circuit television (CCTV) 504, a temperature control system 506 (including a temperature monitor and a temperature controller) and a lighting and heating controller 508.

[0093] The enclosure 502 may be used for chick rearing in differing chromatic conditions. The enclosure 502 is light-tight and is illuminated by four banks or arrays of light emitting diodes (LEDs) 510 in the roof of the enclosure 502 (e.g. on an inner surface 512 of the enclosure lid 514). Three different lighting conditions, each with a 12 hour on/12 hour off periodicity were used in three different experimental conditions.

[0094] The inner walls of the enclosure 502 were lined with alternating black and white vertical stripes 516 to which the chicks accommodate preferentially. The black and white vertical stripes 516 had a spatial frequency of about 4-8 cycles/degree, and depending on the location of the respective chick within the enclosure 502, the black and white vertical stripes 516 provided light with a spatial frequency of 4-8 cycles/degree.

[0095] The chicks were supplied with a thermostatically controlled air supply at temperatures between about 28°C and about 32°C. A remote supply of food and water were provided *ad lib* without affecting the lighting conditions.

[0096] Cleaning of the enclosure was achieved with a remote cleaning system by means of a built-in cleaning and venting system, without the need to open the enclosure 502.

[0097] During rearing over a period of time, for example over a 14-day to 28-day period or a 42-day period, chick behaviour and health were kept under observation and monitored via the CCTV 504.

[0098] Batches of day-old chicks were raised under white, red or blue wide spectrum lighting conditions for about 2 to 4 weeks, and the refraction of each eye was determined

by streak retinoscopy and by computerised infrared photorefraction. Ocular dimensions were determined by ultrasonography (Sonomed 1500).

[0099] Lighting of the enclosure 502 was achieved using the banks of light emitting diodes (LEDs) 510 emitting preferentially white, red or blue light. Four banks of LEDs 510 were arranged in the roof of the enclosure 502 with a disposition or arrangement to ensure at least substantially even illumination of the interior of the enclosure 502. Each strip or bank of LEDs may contain about 30 separate LEDs with at least substantially similar emission properties. However, it should be appreciated that each strip of LEDs may contain any number of LEDs in a range of between 10 LEDs and 50 LEDs, for example between 10 LEDs and 30 LEDs or between 20 LEDs and 40 LEDs.

[00100] Luminance at the centre of the enclosure 502 measured with a colour sensitive photometer (LX107, Digital Instruments LT Lutron, Taiwan) was at least substantially equal for red and blue lighting conditions at about 3.1 and 3.2 foot candles respectively. Luminance from the white emitting LEDs at the centre of the enclosure 502 was about 10.9 foot candles.

[00101] FIG. 6 shows a plot 600 illustrating the emission spectra of the light emitting diodes (LEDs) used for chick rearing, according to various embodiments. The spectra were determined by spectroscopic analysis with a high resolution spectrometer (HR 2000, Ocean Optics, Dunedin, FL, USA). The plot 600 shows the emission spectra for the white LEDs 602, the blue LEDs 604 and the red LEDs 606.

[00102] As shown in FIG. 6, the spectral emission of the blue LEDs 604 is between about 430 nm and about 550 nm with a sharp peak at about 480 nm and a short tail into the green region to about 540 nm, while the spectral emission of the red LEDs 606 is between about 550 nm and about 700 nm with a sharp peak at about 640 nm. The spectral emission of the white LEDs 602 is between about 410 nm and about 840 nm, with a sharp peak at about 450 nm in the blue region of the spectrum and a broad area of increased emission at between about 500 nm and about 700 nm having a broad peak at about 536 nm in the green region and an extended emission into the far-red region.

[00103] All three types of LEDs have some green emission, with the red LEDs having the least amount of green emission. While the proportion of green in the emission of the red emitting LEDs may be low, the green emission is near the peak of the cone spectral

sensitivity curve of a human such that a small amount of green light may be sufficient to provide effect on accommodation of the eye, and which is supported by the results of raising chicks in the three different lighting conditions as described below.

[00104] The refractive results of raising batches of chicks for about 14 days, about 21 days and about 28 days in red (+green) or blue (+green) lighting conditions are shown in Table 1 and FIG. 7. It can be seen that chicks raised in predominantly red light became myopic, while those raised in predominantly blue light became hyperopic with a significant difference between mean refractions in these two conditions ($p < 0.001$) at all three time intervals, while excess blue resulted in hyperopia with a significant difference between the mean refractions in these two chromatic conditions ($p < 0.001$). Both right and left eyes in individual chicks behaved similarly as the results shown in Table 1

[00105] Also as shown in Table 1, the myopic eyes resulting from red light rearing had longer vitreous chamber lengths than the vitreous chamber in the blue-raised hyperopic eyes, indicating that the myopia was axial myopia, similar to the type of myopia generally seen in myopic human children.

Table 1 : Refractive status of the eyes of chicks of rearing in either excess red or excess blue lighting conditions.

	Refractive (dioptres) (mean ± SD)			Vitreous length (mm) (mean ± SD) at 14 days
Rearing Light	14 days	21 days	28 days	
Excess Red	-1.62 ± 0.54	-2.21 ± 0.21	-2.83 ± 0.25	5.55 ± 0.11
Excess Blue	+3.06 ± 0.29	+4.21 ± 0.18	+4.55 ± 0.21	4.73 ± 0.72

[00106] FIG. 7 shows a plot 700 of histograms of mean refractive status of randomly selected eyes from each chick reared for 14 days, 21 days or 28 days in predominately red or predominately blue lighting conditions. One eye was chosen at random from each chick at each time interval.

[00107] As shown in FIG. 7, those raised in red light (with some green) were myopic at each time interval,, with increasing severity over a 28-day period, while those raised in

blue light (with some green) were hyperopic at each time interval, with progressive hyperopia over a 28-day period. Mean values and standard deviations, in dioptres, are indicated for each combination of duration and chromatic nature of the light in which chicks were raised. In FIG. 7, "*" indicates probability difference (p<0,001) between red light and blue light rearing at each time interval.

[00108] The myopic chicks raised in predominantly red light had significantly longer vitreous chamber lengths at 14 days than the hyperopic chicks raised in predominantly blue light ($p < 0.01$), as shown in Table 1.

[00109] In addition, chicks were raised in red light for 21 days and refracted at 14 days and 21 days at which time interval the degree of induced myopia was determined. The chicks were then returned to the enclosure for a further 21 days in blue lighting conditions and refracted at 14 days and 21 days to determine whether the myopia induced by red light rearing may be reversed to hyperopia by blue light rearing.

[00110] FIG. 8 shows a plot 800 of histograms of mean refractive status of randomly selected eyes from each chick raised for 21 days in predominantly red light and subsequently for 21 days in predominantly blue light conditions. One eye was chosen at random from each chick at each time interval Mean values and standard deviations, in dioptres, are indicated for each combination of duration and chromatic nature of the light in which chicks were raised.

[00111] In excess red light rearing, the eyes became progressively myopic but when the lighting was changed to an excess of blue, the previous progressive myopia was converted to progressive hyperopia. Mean values and standard deviations, in dioptres, are indicated for each combination of duration and chromatic nature of the light in which chicks were raised.

[00112] Furthermore, chicks were raised in blue light for 21 days and refracted at 14 days and 21 days at which time interval the degree of induced hyperopia was determined. The chicks were then returned to the enclosure for a further 21 days in red lighting conditions and refracted at 14 days and 21 days to determine whether the hyperopia induced by blue light rearing may be converted to myopia by red light rearing.

[00113] FIG. 9 shows a plot 900 of histograms of mean refractive status of randomly selected eyes from each chick raised for 21 days in predominantly blue light and

subsequently for 21 days in predominantly red light conditions. One eye was chosen at random from each chick at each time interval. Mean values and standard deviations, in dioptres, are indicated for each combination of duration and chromatic nature of the light in which chicks were raised.

[00114] In excess blue light rearing, the eyes became progressively hyperopic but this was reversed to progressive myopia by subsequent excess blue light rearing.

[00115] Excess blue light rearing is more effective in inducing hyperopia than was excess red light in inducing myopia. Additionally, excess blue light was more effective in converting red light-induced myopia to hyperopia than was excess red light in converting blue light-induced hyperopia to myopia.

[00116] Therefore, it is shown in chicks that an alteration of the chromaticity of light in which they are reared may induce myopia (excess red light), or hyperopia (excess blue light) and that excess red light-induced myopia may be converted to hyperopia by subsequent exposure to excess blue light.

[00117] Separately, it was determined that a short period of 2 hours of excess blue light rearing, with 10 hours of excess red light rearing and 12 hours of darkness may prevent or minimise the myopia that is expected from the longer period of red light rearing.

[00118] This shows that a short exposure per day to excess blue wavelengths may be sufficient to prevent or minimise myopia in vulnerable children (e.g. those with a family history of myopia) or to halt or slow the progression of myopia in those children who had already developed myopia.

Discussion

[00119] The results obtained from raising chicks in controlled conditions of predominantly red or predominantly blue lighting provide support that the growth of the young eye may be conditioned by the vergence of light traversing the retina and more specifically by the relative photon catch in the tips and bases of the photoreceptor OS. In conditions of convergent light traversing the retina (hyperopic blur) that may result from lens-induced hyperopic blur or from the effects of excess red light that is also convergent

as it reaches its point of focus just beyond the tips of the OS, the response is ocular elongation and the development of axial myopia.

[00120] A difference exists between the pattern of eye growth resulting from lens-induced ametropia and that from an excess of red or of blue wavelengths in the light incident upon the eye. In the young eye, the altered eye growth induced by lenses ceases when the eye has grown to compensate for the strength and sign of the lens inducing ametropia. For example, the wearing of a +6D lens inducing a hyperopia of +6D and the wearing of a -6D lens inducing a myopia of -6D, may not result in any further change in refraction with longer periods of lens wear.

[00121] In contrast, the effects of chromaticity are continuous. Where the young animal eye or the young human eye is exposed to excess red light, the eye continues to elongate where the excess of red light continues to be present and where the young eye retains its plasticity and its ability to alter its growth pattern in response to environmental factors such as exposure to light of an abnormal chromaticity.

[00122] In the chick eye, it has been estimated that the difference in vergence of red light as compared with blue is about 1.5 dioptres (Mandelman T, Sivak JG. Vision Res 1983;12:1555-59; Rohrer B, et al., J Physiol 1992; 449:363-376). The results in accordance with various embodiments show a difference in vergence between the red and green light or between the blue and green light, each of which may affect the pattern of ocular growth and refractive development, of the order of about 0.75 dioptres. In the case of induced hyperopia, with a refractive error of around +3.0D (+3.0 dioptres) at about 14 days and +4.50D at about 28 days for those chicks raised in predominantly blue light (with about 40% green content), the effect of the difference between the blue and green wavelengths resulted in a continuously induced change in refraction in the chick eye in the order of over +1.00D per week. The induced myopia in chicks raised in predominantly red light was of the order of about 0.75D per week, although this result may be affected by the presence of about 20% blue region light in the light emitted by the red LEDs.

[00123] The mechanism by which the eye is able to respond to an imbalance in the summated photon densities at the tips and bases of the OS of red sensitive and blue sensitive cones respectively may require further determination. Nevetheless, it has been

determined that photons directed laterally into isolated receptor OS generate excitation of the OS limited to a narrow band (3 μm) of the OS with no distal or proximal diffusion (Lamb TD, et al., J Physiol 1981;319:463-96), a situation that would be necessary if the retina were able to differentiate between photon catch in the distal as compared with the proximal OS.

[00124] Outdoor activity may protect against myopia progression while indoor activity and close work (e.g. close work under tungsten illumination), such as involving reading and writing, may be associated with the development of myopia. Indoor activity may be a factor causing the development of myopia irrespective of close work.

[00125] In considering the role of indoor activity in the etiology of childhood myopia, generally much indoor activity is conducted in artificial light, for example with tungsten lighting. Tungsten incandescent lamps have a continuous emission spectrum from about 300 nm to about 1400 nm (beyond the visible spectrum) with most of the emission at about 600 nm or more (red to infrared). Their emission spectrum contains a small proportion of green emission and very little blue, i.e. the spectral emission of tungsten lamps bears some similarity to that emitted by the red emitting LEDs that caused chicks to become myopic.

[00126] Currently, tungsten incandescent lamps are being replaced by long-lasting energy saving fluorescent lamps. While these lamps characteristically emit ultraviolet light and some blue wavelengths like most fluorescent lamps, they have a discontinuous emission spectrum with several intense peaks in the green and red portions of the visible spectrum the emission pattern depending on the phosphors used to create the fluorescent output.

[00127] Photography of an indoor scene in different intensities of daylight, tungsten lighting and in low energy fluorescent lighting was carried out to illustrate graphically the blue content of daylight and the red content of both tungsten and low energy fluorescent lighting and the relative amounts of red, green or blue wavelengths for each condition of illumination are as shown in FIG. 10 where the indoor scene was photographed in dull or bright diffuse daylight, with tungsten illumination at two different intensities and with illumination from low energy longlasting fluorescent lamps.

[00128] FIG. 10 shows a plot 1000 of histograms of the chromatic content of a same indoor scene lit by different illumination sources, for example lit by cloudy daylight (Daylight 1), bright daylight (Daylight 2), a low energy long-life fluorescence illumination source (Longlasting), one tungsten light (Tungsten 1) and two tungsten lights (Tungsten 2) providing brighter illumination. Daylight lighting is predominantly blue while artificial lighting is predominantly red.

[00129] In FIG. 10, for each illumination (e.g. Daylight 1, Longlasting, etc.), the left-most result represents the proportion of red region light, the middle result represents the proportion of green region light and the right-most result represents the blue region light.

[00130] As shown in FIG. 10, the proportions of red, green and blue region lights are substantially equal in dull cloudy daylight (Daylight 1) with a ratio of red 28% : green 37% : blue 35%, and there is a slight increase in the green and blue region lights in bright daylight (Daylight 2) with a ratio of red 28.5% : green 34.5% : blue 37%. There was a small preponderance of blue and green region lights (i.e. blue and green contents) for daylight illumination.

[00131] In contrast, longlife fluorescence and tungsten illuminations have a preponderance of red region light (i.e. red content), that increases with brighter tungsten lighting. The low energy long-lasting fluorescent lighting (Longlasting) provided illumination of a ratio of red 60% : green 32% : blue 8%. One tungsten light illumination provided illumination of a ratio of red 54% : green 27% : blue 19%, while illumination from two tungsten lamps showed a ratio of red 58% : green 29% : blue 13%.

[00132] FIGs. 11A to 11E show photographs of various outdoor scenes with their respective chromatic content. The respective chromatic content of a variety of outdoor scenes show considerable variation in the proportions of red, green or blue content.

[00133] The photograph 1100 of a cloudy sky shows a substantially equal contribution from each colour of green 1102, blue 1104 and red 1106, the photographs 1110, 1120, 1130, of sunlit open scenes show a preponderance of blue and green colours (respectively 1112 and 1114, 1122 and 1124, and 1132 and 1134) and a reduced proportion of red (respectively 1116, 1126, 1136), while the photograph 1140 of a sunset scene shows a preponderance of red colour 1146 compared to green 1142 and blue 1144.

[00134] Outdoor activity may protect against myopia progression while indoor activity and close work (e.g. close work under tungsten illumination), such as involving reading and writing, may be associated with the development of myopia. Indoor activity may be a factor causing the development of myopia irrespective of close work.

[00135] This is because indoor activity (including close work), for example undertaken in artificial lighting based on tungsten or long lasting low energy fluorescent lamps having a spectral composition with a preponderance of long wavelength red light and a reduced blue content, in addition to a proportion of green light, mimics the conditions of chick rearing as described above that leads to the development of myopia.

[00136] The protective effect against myopia associated with outdoor activity, may be due to the chromaticity of outdoor lighting that may contain a preponderance of blue light, an adequate content of green wavelengths and a low red content, thus mimicking the spectral composition of light that led to the development of hyperopia in chicks that similarly may be protective against myopia in human children, as has been demonstrated in chicks as described above.

[00137] The chromatic content of light incident upon the eye may determine the ocular and refractive development. The results as described above may be applicable in children, such that modification of the chromatic composition of light to which the eye is exposed by increasing the proportion of blue light as against that of red light and including an adequacy of green light so as to maintain accommodation so that the focal plane for the green light may pass through the mid-points of the photoreceptor outer segments, may ensure a preponderance of photon density in the OS bases that may be protective against the development of myopia or its progression.

[00138] The conversion to hyperopia by a change (e.g. a short exposure to blue light) to blue light rearing from myopia induced by red light rearing in chick as shown in FIG. 8, may be applicable in human children where myopia developed in human children may be reversed by chromatic manipulation of visual images at any early age. The amount and duration of blue light exposure required to overcome the myopia induced by excessive exposure to longer wavelength red light from artificial lighting indoors may be such that it is insufficient to affect the retina adversely (e.g. "blue light hazard").

[00139] Therefore, the inclusion of green light to maintain the focal plane of the retinal image in the mid-points of the photoreceptor outer segments (OS) together with an increase in the proportion of blue light focused in front of this focal plane and a decrease in the proportion of red light focused behind this focal plane may cause the young eye to develop towards hyperopia. Altering the balance of blue and red light in favour of an increased proportion of red light (in the presence of an adequate proportion of green light) has the opposite effect, causing the development of myopia. In addition, myopia induced in the young eye by an excess of red light may be subsequently reversed by exposure to an excess of blue light providing support for the use of chromatic manipulation in the prevention of childhood myopia or slowing or halting the progress of myopia that has already developed.

[00140] While the invention has been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.