interview

UNDERSTANDING RISKS OF PHOTOTOXICITY ON THE EYE

Certain portions of the light spectrum can be detrimental to ocular health and lead to accelerated eye ageing and diseases. With an influx of modern short wavelength light sources on the market, the human eye is susceptible to greater exposure to these lights. Prof. John Marshall, Professor of Ophthalmology at University College London, recipient of the Junius-Kuhnt Award and Medal for his work on AMD, sheds some light on phototoxicity risks and the need for prevention for *Points de Vue.*

PROFESSOR JOHN MARSHALL
University College London

***Points de Vue*: Professor Marshall, could you describe some of the research areas you have been involved with over the years that are linked to vision and light?**

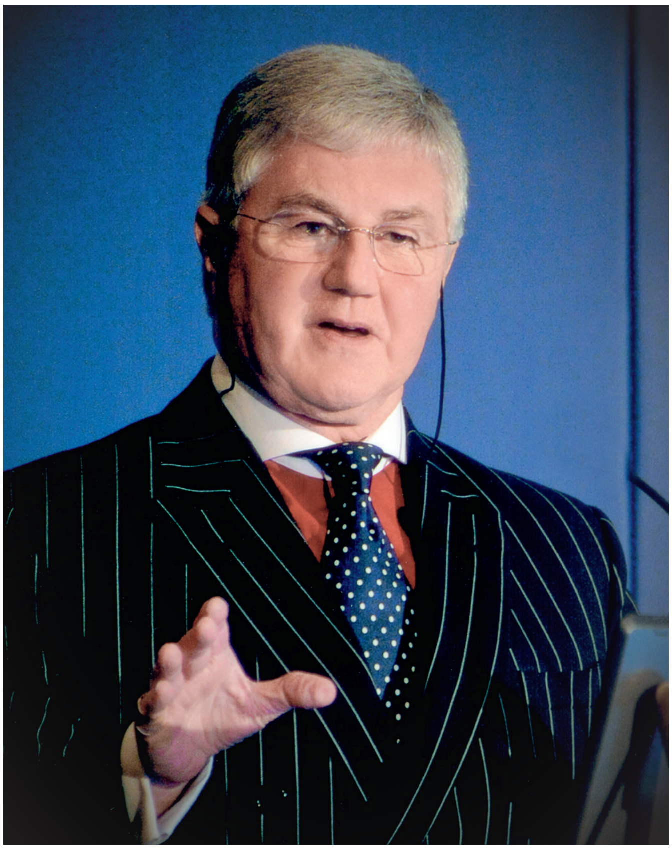
Prof. John Marshall: I started in vision back in 1965, when I was given a PhD grant with the Royal Air Force to investigate the potential damaging effects of lasers on the retina. At that time we needed to have a much better understanding of how light interacted with the retina and what mechanisms could potentially damage it. Collectively our work together with some German and American teams developed a data base that formed the basis for the international codes of practice to protect individuals against the potential damaging effects of lasers. It also extended into the potential damaging effects of incoherent light. These data were also incorporated into the codes of practice used by large international organizations such as the World Health Organization (WHO), the United Nations environmental programme and the International Red Cross.

KEYWORDS
UV, blue light, photo toxicity, laser, cataract, AMD, Retinitis Pigmentosa, RP, IOL, Crizal® Prevencia®, prevention

After looking at the effects of the acute intense light I become very interested in the effects of chronic irradiation with incoherent light such as sunlight and commercial and domestic light sources in the UK. Our subsequent research showed that the retina was most sensitive to short wavelength visible radiation in the blue region of the spectrum and strangely the cones were more vulnerable than the rods in diurnal animals. Previous data which has confused a lot of the literature was derived from experiments on rats and mice that have predominantly rod retina and as a consequence showed damage to rods.

Subsequently, was your transition into studying the effects of incoherent light, away from lasers, more of a personal interest?

Originally it was personal interest because light is light, whether generated within a laser or an incandescent bulb. Light sources emit photons. I was interested in the interaction between photons and biological tissue, and how photons gave rise to the sensation of vision. Eventually I got interested in how excessive exposure, whether high level, high power or prolonged periods of exposure, had



the potential to damage the visual system. From the evolution standpoint our eyes were designed to have roughly 12 hours of light and roughly 12 hours of dark, something that modern lifestyles have changed considerably.

From your personal point of view, do you think changes in illumination have had an impact in this regard?

Yes, because for thousands of years the only light source under man's control was fire found in systems such as burning braid, oil lamps or candles. The next progression in the series was gas lighting, which was also essentially fire. However, all of these sources created heat and a lot of light meant a lot of heat. It wasn't until the advent of the incandescent bulb in the mid-1800s that we had daylight levels of illumination at any time of night or day. Further, with the advent of fluorescent lighting in the 1940s, we could have high light levels without significant actual heat. Unfortunately unlike incandescent bulbs, which produced light mainly towards the red end of the spectrum, fluorescent lighting had emissions in the blue and ultra violet regions. At present, due to environmental concerns of conservation of energy, we are seeing compact fluorescent and LED lights in the market in the name of energy saving, but again these produce ultraviolet and blue light. There should have been much more consultation with the biological vision community before these biologically unfriendly sources were introduced. It is only now that a committee has been formed to consider the unexpected health hazards of such devices. The dermatologic and ophthalmic community could have told the manufacturers that such potential health hazards were certainly not unexpected.

What do you expect the impact of this new form of low energy lighting to be now and in the future?

Researchers on skin have already expressed some concern over ultraviolet and high-intensity blue, increasing the chances of skin problems from commercial and domestic lighting. My concern would be that **any short wavelength radiation involves high-energy photons and can exacerbate the ageing process in our eyes** in a manner similar to how excessive sunlight exposure during your lifetime can lead to ageing effects such as wrinkly skin. Certain wavelengths may well implicate an accelerated ageing process leading

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to an earlier onset of cataract and could also exacerbate other age-related conditions such as age-related macular degeneration. They represent environmental risks factors to which we really do not need to expose ourselves, as incandescent bulbs had illuminated our homes satisfactorily for a hundred years.

Are there any calls to government agencies on the dangers of this new push for low energy light bulbs?

In my opinion there should have been a committee of experts assessing the health hazards of low-energy lighting before they became available in the marketplace and certainly before incandescent bulbs were banned! Unfortunately this is closing the door after the horse has bolted. It should have been more important to consult the relevant experts before making important policy decisions in order to avoid a potential downstream problem.

How does this phototoxicity act on ocular tissue?

High-energy photons in the presence of oxygen give rise to reactive oxygen species that are potentially dangerous for cells. Light damage to the skin is minimised by the surface cells of the skin being constantly replaced by cells from deeper layers, thus simplistically the system is renewed approximately every five days. By contrast the cells that line the inside of the eye, the retina, are in essence an outgrowth of the brain and therefore like all neurons incapable of dividing. The rods and cones have to absorb light and are in the presence of high levels of oxygen. They have developed a mechanism whereby the light-sensitive portion of the cell is constantly renewed on a daily basis. Every hour of every day approximately three to five new light-sensitive membranes are manufactured and every morning on awakening rods lose approximately 30 old membranes to a layer of cells called the retinal pigment epithelium (RPE). Cones lose their old membranes about every four hours during our sleep period.
Over a human lifetime, the RPE cells that also don't normally divide have to contend with huge amounts of degraded biological material. From one's mid-thirties onwards, the RPE cells get progressively clogged with toxic products. At a later stage these waste products lead to further changes between the RPE cells and their underlying blood supply. This sequence of buildup of age-related waste products generated by an attempt to protect the light-sensitive cells against the damaging effects of light throughout a lifetime is the biggest risk factor in age-related macular degeneration (AMD). More light stress produces more debris, and has the potential to accelerate the ageing process. We certainly need some exposure to blue lighting in order to balance our biological well-being and stop us becoming affected by seasonally adjusted disorder (SAD). However this is a requirement for longer wavelength blue light and there is no advantage associated with short wavelength blue light or ultraviolet.

So to expand on this point, do you see a difference in phototoxicity between the bands within the blue portion of the spectrum?

Yes, the longer wavelengths of blues are the blues we need to keep happy and prevent ourselves from getting SAD. **It's the blue light near the ultraviolet and the blue indigo violet that are the most harmful and the wavelengths that we ought to get rid of.** Not all wavelengths cause concern. Only short wavelength photons are individually capable of producing photochemical events, and these tend to be from the short wavelength blue end of the visible spectrum down through the ultra violet. From the red end of the visible spectrum up through the infrared, photons do not have enough energy by themselves to produce photo chemical damage and here damage results by large concentrations of them arriving in tissue, causing vibrational modes which are heat.

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Could you elaborate on the particular ocular conditions that you have some concern about?

Many patient groups that suffer from conditions where the photoreceptor cells or light sensitive cells are most vulnerable have been advised in the past to wear protective eyewear which typically looks "reddish" or "brownish" and such devices filter out harmful wavelengths whilst letting in the useful wavelengths required for vision. Large patient groups such as those with Retinitis Pigmentosa (RP) would be an example of a disease group that benefits from such protection.

Would you contend that from your personal belief that protective eyewear would be useful for people who are in early stages of any other ocular condition?

Several clinicians would advise patients in the early stage of AMD to wear peaked hats and to wear protective eyewear as well. The big problem is that patients do not get good advice currently as to which protective eyewear is going to be helpful; they are merely instructed that the device blocks 100% of ultraviolet, but usually they are given no information on how much blue is transmitted.

What role do you think clinical practice could play in prevention of the ocular problems you've described linked to blue-violet light?

I think the scientific base is pretty incontrovertible: short wavelength visible radiation is more harmful than long wavelength visible radiation. It should be remembered that we do not have any short wavelength photoreceptor cells, blue cones, in our foveas and that the macular region of the retina is protected by the presence of a yellow pigment thus blue plays no role in high acuity vision. We all suffer with foveal tritanopia and as a consequence we lose nothing by filtering out short wavelength blue in terms of our visual life. There is some resistance to wearing highly pigmented protective eyewear because many individuals don't like walking around in bright yellow or brown lenses. This is why **I think the current innovation from Essilor is quite interesting, because these lenses (Crizal® Prevencia®) are apparently transparent, and also reflect blue from the surface while absorbing the ultraviolet.** This innovation is pretty interesting, because they now offer protection without being stigmatised for aesthetics.

Would you suggest that this innovation would be a useful correction that an eye care professional could deliver to a younger patient?

I think it's extremely useful because wearing protective eyewear is similar to wearing sun cream. It won't do any harm and probably it will do a lot of good over the course of one's lifetime.

Earlier, you mentioned the shifts in internal lighting historically over the last hundred years. Do you see the more recent changes as a cause of concern?

Yes, both in terms of domestic and commercial lighting. Although lighting companies are working very hard to try and get rid of potentially harmful wavelengths, they've not been successful so far. The light sources they have produced with filters to filter out the harmful radiation are significantly more expensive compared to the light bulbs in our homes. In terms of fluorescent tubes, there is one sodium line which is almost 40% of the blue light hazard and accounts for less than 8% of the light, but they can't get rid of it, because it facilitates lower costs and ease of manufacture.

What do we need to do to bring a level of public awareness around blue light and its potential harmfulness?

It would be very helpful to bring optometrists and eye care professionals up to date and to make sure they are in full possession of the basic knowledge. They would then be in a position to help their potential clients. Specifically in the field of the cataract surgery, we remove the natural yellow lens and implant a plastic intra-ocular lens; now virtually all intraocular lenses have UV block, and in recent years many IOL companies have introduced lenses with blue blocking or blue attenuating filtration. This is because when you remove the crystalline lens, the retina gets exposed to even more light damaging blue light and ultraviolet.

The benefits of the yellow sort of blue filter IOLs have been raised with the ophthalmologist community. What are your thoughts on this?

In Europe, the proportion of IOLs having blue filters varies from country to country; the highest ratio of blue blocking lenses is in France, where I believe 70% of the lenses have yellow filtration. It is less in many other countries. In the UK, ophthalmologists sometimes prefer clear lenses over blue blocking ones. They would like to see more established evidence of the benefits of blue blocking. There is mixed opinion on the subject, although experimental evidence does point in that direction. It comes down to education at the end. The mindset of ophthalmologists is progressively moving, but these things take time. When it comes for me to have my cataracts removed, I will certainly have a blue-filtering IOL implanted.•

Interviewed by Andy Hepworth

"Wearing protective eyewear is similar to wearing sun cream. It won't do any harm and probably it will do a lot of good over the course of one's lifetime."

BIO

Professor John Marshall
University College London

Professor John Marshall is the Frost Professor of Ophthalmology at the Institute of Ophthalmology in association with Moorfield's Eye Hospital, University College London.

He is Emeritus Professor of Ophthalmology at King's College London, Honorary Distinguished Professor University of Cardiff, Honorary Professor the City University and Honorary Professor Glasgow Caledonian University.

Primarily, he has concentrated his research on the inter-relationships between light and ageing, the environmental mechanisms underlying age-related, diabetic and inherited retinal disease, and the development of lasers for use in ophthalmic diagnosis and surgery.

He invented and patented the revolutionary Excimer laser for the correction of refractive disorders.

He also created the world's first Diode laser for treating eye problems of diabetes, glaucoma and ageing.

Professor Marshall has been the recipient of several awards: the Nettleship Medal of the Ophthalmological Society of the United Kingdom, the Mackenzie Medal, the Raynor Medal, the Ridley Medal, the Ashton Medal, the Ida Mann Medal, the Lord Crook Gold Medal, the Doyne Medal of the Oxford Congress, the Barraquer Medal of the International Society of Cataract and Refractive Surgery and the Kelman Innovator Award of the American Society for Refractive and Cataract surgery. More recently in 2012 he received the Junius-Kuhnt Award and Medal for his work on AMD.

Professor Marshall has authored over four hundred research papers, 41 book chapters and 7 books.

KEY TAKEAWAYS

- Photons interact with biological tissue and may potentially lead to ocular health hazards.
- The red end of the visible spectrum up to the infrared can generate heat, while short wavelength photons can produce photochemical damage and accelerate ocular ageing process.
- Short wavelength blue-violet may exacerbate age-related macular degeneration (AMD) and UV radiation can potentially lead to earlier onset of cataract.
- Not all wavelengths cause concern. Long wavelength blue light is needed to balance biological well-being and Seasonally Adjusted Disorder (SAD).
- Selective photo-protection (filtering UV and short blue-violet light) is a necessity for eye health in the long term.
- Crizal® Prevencia® lenses selectively filter UV and the bad part of the spectrum while allowing good blue light to pass through. They maintain perfect transparency.