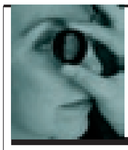

Digital TV and the eye

Dr Brian Evans proposes a theory that may change the way we think about visual processing, particularly the perceived cylinder variation experienced by albinos

I have been a telecommunications engineer for more than 30 years. In 1988 I was the first to propose the switchover from analog to digital television[1] so have followed its progress with interest ever since. There is an uncanny similarity between the processing of digital TV pictures and the visual processing that goes on behind the retina. Both depend heavily on data compression such as jpeg and mpeg technologies or their biological equivalent.

Compression techniques are family affairs. Some families are good at seriously heavy compression whereas others provide better quality images when only light data compression is required. Some images compress easily under one family whereas other pictures benefit from a different technique. Scene by scene the digital TV encoder tries a number of techniques in parallel then makes an informed choice as to which one is best.

It is the same in the eye. Image data reduction (compression) occurs behind the retina and the coded information is sent through the optic nerve to the visual cortex for deciphering. Some studies have shown[2] that the eye has more than one data reduction technique at its disposal. It can take up to a few seconds for the regular eye to decide which one is best for that particular scene. Within the image processing regime there is also an opportunity to sharpen the picture. For hypoplasia of the optic nerve, however, in which data flow is significantly restricted, the final choice of data reduction algorithm may be sub optimum. One of the other briefly tried but quickly discarded compression choices may have been better – hence the reports of shortlived functional improvement in visual acuity when the scene changes.

With the advent of high definition TV there is a now constant need to maintain a sharp focus on screen. If focus should drift away it is important to signal this to the camera operator and to indicate quickly in which direction the focus should be 'pulled'. One way of achieving this is to use a camera with two focal planes spaced a small distance apart. If there is a sharp focus on the principal focal plane but a fuzzier image on the adjacent focal plane then all is well. If the situation is reversed then there is a need to adjust focus. It then only requires some simple logic to decide on the direction of the focus adjustment.

I suggest that this dual plane quick focus mechanism also occurs in the human eye. Images are formed at the

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edge of the foveal well (the adjacent focal plane) as well as at the base of the foveal well (the principal focal plane). Just like the HD camera the eye has, in effect, two focal planes. The avian eye has two separate flat foveas but a similar focusing logic can be applied.

But what happens if the fovea does not have a regular well but is flat or raised instead? The bio logic is still in place but the focus/defocus images are now mixed or reversed. We would experience the same confusion if our plumber connected our shower mixer valve the wrong way round to the hot and cold pipes. I therefore expect people with flat (albino) or raised (maculopathy) foveas to have difficulty in maintaining accommodation. Their subjective visual acuity may then be significantly worse than the pathology suggests.

Is there a way around this? Without the benefit of a focus direction signal the camera operator might elect to jerk the focus off one side to a blur then pull back gently until focus is restored. Is this what has happened in the West Wales trial of +2.00DS addition bifocals for children with Down's syndrome? Or perhaps this may explain how so called 'teenage malingerers' find their visual acuity can be briefly restored by a +5.00/-5.00DS jerk sequence of trial lenses. Of particular interest is Dr JM Woodhouse's recent findings (*Optician,* News, May 2 2008) that children with Down's no longer need the bifocals after a few years of wear. Their eyes appear to have learned to accommodate successfully from what was originally intended as a fix but, in practice, has become a training regime.

The albino experience

I have type 1B ocular cutaneous albinism and have attended a number of albino support conferences around the world. Perhaps the most striking characteristic of adults with albinism is not their unpigmented appearance but how few of them choose to wear their spectacles. They have drawers full of them at home but most prefer to do without. Why is this? Has the international optometry profession let them down or is something unexpected happening in their eye?

For the past few years I have been a regular patient at my local optometrist where my poor eyesight gets checked by each new intake of pre-registration optometrists. My vision is about 6/15 (though I can tweak it to 6/9 with a Galilean contact lens/glasses combination) and my refraction is approximately +2.00DS/- 6.50D x180 in both eyes.

However, there is a problem. The script cylinder parameter is not constant but changes frequently. A cylinder value of about 6.75DC is found but immediately after refraction the cyl correction drops from 6.75 to 6.00DC.

This highlights a number of issues. The first is the extended time taken by the pre-reg to do the refraction. An autorefractor would perform the same task in about a second. My adjacent autorefraction results are generally consistent with one another whereas the manual refractions are not.

The exact presentation sequence of trial lenses in the extended manual refraction can vary whereas, I presume, the autorefractor always follows a similar trial lens protocol. Any possible autorefractor focus jerk will always be the same whereas the focus jerk applied in the manual refraction is unknown.

Why does the cylinder parameter vary wildly while the sphere parameter remains fairly stable? To answer this question I first needed a subjectively sensitive way to measure small changes in astigmatism.

I have used a radial grating chart

RADIAL GRATING CHART

Figure 1

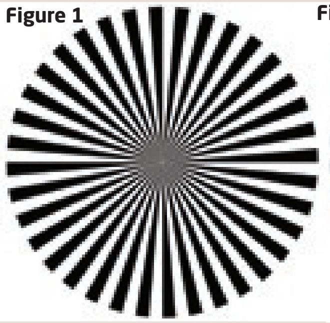


Figure 2

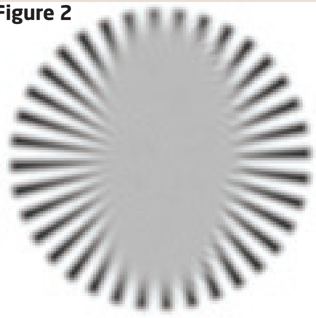
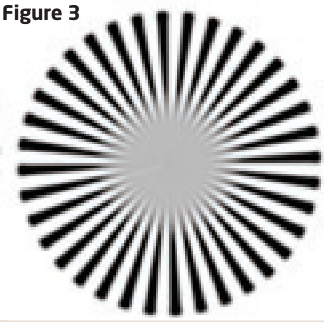


Figure 3



For regular 6/6 visual acuity the diameter of the chart should subtend 22.9 minutes of arc. (This is a trignometrical re-expression of the Snellen 5 minutes of arc requirement.) A 6/6 visual acuity is indicated if one is able to discern the outer edge of a 3.82cm diameter chart at a distance of 6 metres. In practice the size of the printed or on-screen chart is three times this minimum diameter. Being able to discern the outer edge thereby indicates a 6/18 VA whereas the ability to follow the spokes further into the centre indicates an increasingly better visual performance. Too large a chart (too great a subtended angle for an individual visual acuity) can lead to optical delusion as the high spatial content of a big chart confuses the visual cortex. Two examples of refractive error are shown. Figure 2 shows the added effect of an uncorrected astigmatism. The radial grating chart provides a sensitive indication of astigmatism. As little as 0.25DC change in cyl correction will show a marked subjective change in the shape of central grey area. Figure 3 shows the effect of a spherical refractive error.

(Figure 1) which is a modification of the familiar but under-used standard fan and block test chart.

For my tests I choose a distance and test chart size that allows me to see the black/white spokes of the outer third of the radial grating chart quite well whereas the centre of the chart is a mid grey blur. For any visual acuity and for any distance there is always a chart size that will appear to be clear at the edges and fuzzy in the middle.

Uncorrected astigmatism will blur some parts of the chart more than others. For a 'with the rule' astigmatism the 3 and 9 o'clock spokes may be seen a good way into the centre of the chart whereas the 12 and 6 o'clock spokes will be more difficult to discern (Figure 2).

A full correction of astigmatism should allow all spokes to be seen equally clearly – with the proviso that the centre of the chart may still be a blur due to any residual spherical refractive error (Figure 3). For someone with good vision this change in grey area is easily demonstrated by viewing the chart through a cross cyl lens so as to modify the visual acuity of individual spokes.

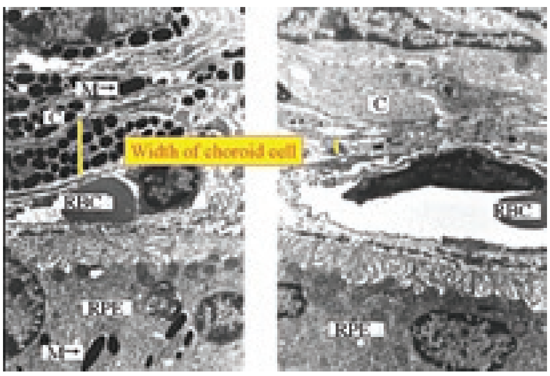


Figure 4 A section through the eye of a regular pigmented mouse and an albino mouse. The black melatonin bricks can be seen in the pigmented mouse eye but not in the albino. Image courtesy of Dr Murray H Brilliant, University of Arizona

Static tests

- **Primary position.** I make a mental note of the size and shape of the central grey area which is beyond the limit of my visual acuity. It is fairly symmetrical.
- **Head turn.** I maintain my forward gaze but turn my shoulders to each side. The central grey area changes size and shape.
- **Head on the side.** I tip my head to the left and right. The radial grating chart is ideal for this test because I can tip my head 20 or 30 degrees (two or three spokes) either way – yet still see the same test pattern. The central grey area changes size and shape once again.
- **Eye turn.** This test requires a prism to shift gaze angle. I first view the chart in the straight ahead position but then introduce a 6 dioptre prism to shift the orb left or right – while still keeping my head straight ahead. The central grey area changes size and shape once again.
- **Yoke prism.** This test uses yoke base-up/base-down prism to jointly modify both the up-down gaze angle and head position. The central grey area changes size and shape once again.

In both my and other albino eyes the gaze angle and head position have a marked effect on refraction and nystagmus. In my eye the prism induced changes vary between 0.75 and 1.00DC. Accommodation, head position and focus jerk introduce a further 1.00DS variation. Thus my own required cylinder correction can vary from 5.25 to 7.25DC – dependent on a number of variables. The good news is that nearly all this variation is eliminated with cycloplegia.

Possible explanations

Many people with albinism have discovered that their best vision (null point) can be achieved with head down, head tilt and an upward gaze. Is this a dynamic minimum super position of separate interferences from gaze and head muscles? Does the US fashion for behavioural yoke prism optometry have a firm scientific base after all?

I am tempted to believe that in some eyes the crystalline lens is subject to asymmetrical forces that dynamically induce irregular astigmatism into the lens. These asymmetries can either be reduced under cycloplegia or as a result of the tenotomy surgery practised by Dr Richard Hertle in Pittsburgh. These variation may, perhaps, be completely avoided with a clear lens exchange.

Perhaps the ciliary body in the albino eye warps under the influence of neighbouring muscles. Dr Murray Brilliant at Tuscon has shown that the choroid of the albino mouse eye is only a third of the size of that of a regular mouse eye. The missing two thirds is made up of black melatonin bricks that probably serve to stiffen the regular structure (Figure 4)

Chair time must be substantially reduced if these variations are to be explored routinely. I believe that we need a straightforward OCT clinical test that can quickly measure the variable asymmetry in the crystalline lens which occurs over a range of gaze and head angles. With such clinical information we might be able to advise difficult patients of more useful therapies than a drawer full of unused glasses.

References

1 The future of digital television in the United Kingdom. BT Evans. Home Affairs Committee. *Future of Broadcasting*; 1988; 22 June, pages 329-337.

2 Dynamic predictive coding by the retina. Hosoya, Baccus, Meister. *Nature*, 2005; Vol 436 12.

● **Dr Brian Evans** is currently studying optometry in Manchester