ACNR JF05 17/12/04 10:29 pm Page 22

Visual Stress in Neurological Disease

Initial observations

Difficulty with reading (dyslexia) can sometimes be reduced by wearing coloured glasses, a claim first made by Helen Irlen in 1983.[1] Initially, the claim was dismissed as little more than a novelty effect[2] but as scientific evidence slowly accrued it became clear that coloured glasses can indeed offer an effective treatment. It is not dyslexia that the glasses treat but the visual stress[3] with which dyslexia is sometimes associated. Removal of the visual stress using coloured filters allows individuals with dyslexia to expose themselves to print for longer. In many instances this facilitates reading acquisition, but it does not necessarily remove the need for specialist teaching.

Visual stress

The symptoms of visual stress include perceptual distortions and eye-strain. The distortions may involve apparent movement of letters or words within text (the letters 'wobble', 'fly off the page'), blurring or fading of letters, changes in the apparent size and spacing of letters, patterns appearing in the dark print or the white space (sometimes described as 'worms', 'rivers' or 'waterfalls'), and colours appearing in blobs across the page or around words. The visual symptoms can be accompanied by nausea, dizziness, discomfort or even eye pain, often attributed to 'glare' from the page.[4] The symptoms are not exclusive to visual stress, but can arise from other optometric anomalies (e.g. binocular instability), so an optometric examination is necessary before the symptoms can appropriately be attributed.[5]

Coloured filters: overlays and lenses

Visual stress can often be removed using coloured filters, either coloured sheets of plastic placed upon the page (coloured overlays) or coloured ophthalmic lenses worn in spectacles. Surprisingly perhaps, there is no particular colour that is suitable because each individual benefits from their own individually selected colour.[6,7] This means that a sufficiently large number of colours must be assessed in order to find the best for an individual. The Intuitive Overlays come in a pack of 10 that can be combined two at a time to provide a pallet of 30 colours, sufficient to identify most of the individuals likely to benefit from coloured filters.[8] The overlays are useful as an inexpensive screening device, but filters worn as glasses often provide a more effective treatment: not only can they be used for tasks other than reading, but recent techniques for ophthalmic tinting mean that the appropriate colour can be selected with greater precision. The appropriate colour can sometimes improve reading speed quite dramatically, by a factor of two or three, but colours that differ from the individual optimum by as little as 6 just-noticeable-differences have little benefit.[6]

Assessment

When the overlays prove beneficial, the appropriate colour is perhaps best selected using the Intuitive Colorimeter, a device that shines coloured light onto a page of text and allows the hue and saturation (strength) of the colour to be varied independently at constant brightness.[9] The optimum colour can then be selected rapidly by successive approximation under conditions of colour adaptation. Once selected, the required colour is made up in tinted trial lenses and assessed under natural viewing conditions.[4] The lenses are designed to provide the appropriate colour under white fluorescent lighting (since this is the most ubiquitous) and to do so with as smooth a spectral transmission as possible, thus reducing the variation from one type of lighting to another. This variation is not sufficient to remove the benefit, despite the precision required.[6] Any necessary adjustments to the tint can be made by varying the combination of trial lenses, and the selected combination then forms a prescription that is sent to a manufacturing optician for making up in spectacle lenses that incorporate any refractive correction necessary.[4] The patent for this system is owned by the MRC, who awarded the licence to one manufacturing optician based in the UK.

The overlays provide a surface colour (the eyes are adapted to white light) whereas the lenses have an effect similar to that of changing the colour of the lighting, and this may be why the optimum colour of an overlay differs from that of lenses.[10]

Professor Wilkins is currently Head of the Visual Perception Unit at the University of Essex, and is co-ordinating research on the use of coloured filters of various kinds in the treatment of reading difficulties, photosensitive epilepsy and migraine. He has been responsible for several innovations, including the first demonstration that fluorescent lighting is detrimental to health. He has a wide range of research interests including the neuropsychology of vision, reading and colour, photosensitive epilepsy, migraine, typography, human memory and attention. These interests have helped him formulate the first unified theory of Visual Stress, detailed in his book with this title. His most recent book "Reading through colour" (Wiley, 2003) provides a review of the theory that underpins the use of coloured filters for reading, as well as a guide for practitioners.

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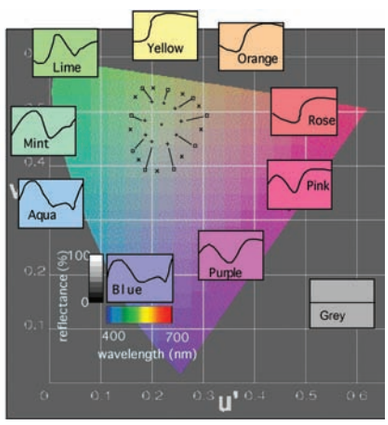
Intuitive Colorimeter/coloriser

The machine has separate controls for brightness hue and saturation

Intuitive Colour Overlays

The points in the inner circle represent the colours of the overlays. The points in the outer circle represent colours provided by two overlays superimposed. The lines join those of similar colour. Panels show the spectral reflectance of the overlays.



Colorimetry procedure

1. Find best hues

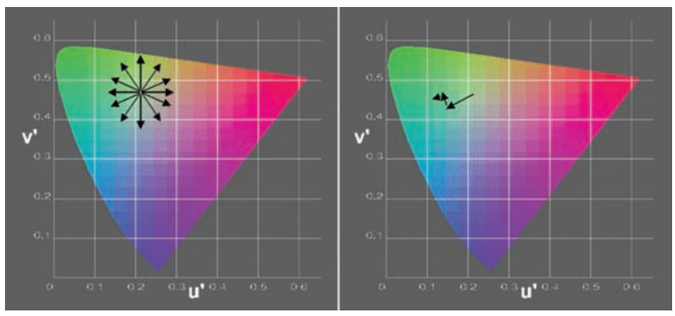
Before adaptation to colour

The saturation is increased and then decreased at each of 12 hues, evenly spaced.

2. Optimise hue/saturation

After adaptation to colour

The saturation is adjusted at the best hue and the hue adjusted at the best saturation. The process is repeated to find a stable optimum.



ACNR JF05 17/12/04 10:29 pm Page 23

Headaches and perceptual distortion

Many individuals who use coloured filters have reported a reduction in headaches. Among these individuals the prevalence of a family history of migraine is twice as great as among those who do not benefit from filters.[11] Although migraineurs may be fluent readers and unaware of perceptual distortion of text, they nevertheless find bolder striped patterns aversive, particularly stripes with spatial frequencies that are epileptogenic for patients with photosensitive epilepsy.[12] This is consistent with several disparate but convergent lines of evidence that in migraine the visual cortex is hyperexcitable.[13] The fMRI blood oxygenation level dependent response to aversive patterns is abnormally large in migraineurs, particularly at epileptogenic spatial frequencies.[14] Preliminary data suggest that coloured glasses can reduce this abnormality.[15]

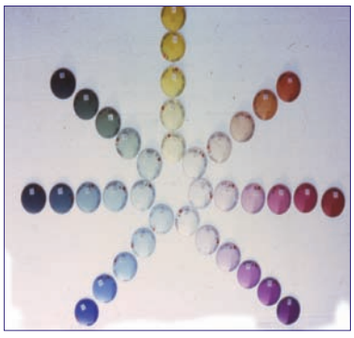
Pathophysiology of visual stress

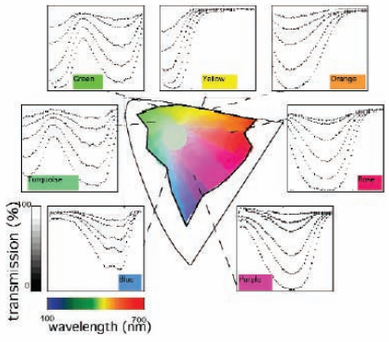
We hypothesise that the perceptual distortions occur because a spread of excitation causes visual neurons to fire inappropriately. According to this hypothesis, the degree of susceptibility to distortions increases with, and reflects, the degree of cortical hyperexcitability. We hypothesise that the cortical hyperexcitability is non-uniform (as is manifestly the case in photosensitive epilepsy[3]), and that the tints redistribute the cortical excitation that occurs in response to a visual stimulus. The redistribution is presumed to occur because of differences in the spectral sensitivity of cortical neurons[16] and the topographic representation of colour in some cortical areas[17]. We hypothesise that comfortable colours redistribute the excitation in such a way as to reduce the excitation in hyperexcitable regions. This hypothesis explains the reduction in perceptual distortions with individually prescribed coloured filters, if these distortions are indeed due to a spread of excitation, as hypothesised above. It also explains the benefit of coloured filters in other neurological disease.

Benefit in autism, head injury and epilepsy

Coloured filters appear to be of benefit not only in dyslexia and migraine but in several other neurological disorders affecting vision. Without exception these are disorders where there is an increased risk of seizures, consistent with the hypothesis that the visual cortex is hyperexcitable. For example, (1) coloured overlays have been shown to improve reading rate in a high proportion of individuals with autistic spectrum disorders;[18] (2) the intolerance to light and sound that follows head injury is often associated with reading difficulties for which coloured lenses may offer benefit, according to preliminary observations.[19] Coloured filters have long been proposed as a possible treatment in photosensitive epilepsy, and the new techniques for ophthalmic tinting have recently been assessed in this condition.[20] Individuals with multiple sclerosis have reported benefit, but clinical trials have yet to be undertaken.

Trial Lenses





Spectral transmissions of the trial lenses (below), and the gamut (below, centre) obtainable with combinations of trial lenses from two dyes of neighbouring colour.

Where to obtain assessment

In the UK, assessment with the Intuitive Overlays is available in many schools and colleges and in many community optometric practices and hospital orthoptic departments. Assessment with the Intuitive Colorimeter is available at more than 200 optometrists and in four ophthalmology departments, and most of these are listed via a link at www.essex.ac.uk/psychology/overlays.

The response to treatment can be immediate and surprising. Some patients prefer to wear their glasses most of the time, and not only for reading; 80% of patients continue to wear their tinted glasses for more than a year,[5,11] although some discontinue use thereafter when they no longer experience symptoms.

The author would be interested to hear from any reader who wishes to conduct a clinical trial of ophthalmic tints in neurological disease.

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